PROCEEDINGS

OF THE

Indiana Academy of Science,

1894.

INDIANAPOLIS, IND.,
OCTOBER, 1895.

INDIANAPOLIS, IND.
WM. B. BURFORD, PRINTER.
1895.

TABLE OF CONTENTS.

ILLUSTRATIONS.

An Act to provide for the Publication of the Reports and Papers of the Indiana Academy of Science.

[Approved March 11, 1895.]

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State, and, Preamble.

WHEREAS, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form, and,

WHEREAS, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement, therefore,

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding. Publication of the reports of the Indiana Academy of Science.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits, to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894. Editing reports. Number of printed reports. Proviso.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, Disposition of reports.

one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage. **Emergency.**

OFFICERS, 1894-95.

PRESIDENT,

AMOS W. BUTLER.

VICE-PRESIDENT,

STANLEY COULTER.

SECRETARY,

JOHN S. WRIGHT.

ASSISTANT SECRETARY,

A. J. BIGNEY.

TREASURER,

W. P. SHANNON.

EXECUTIVE COMMITTEE.

AMOS W. BUTLER,
A. J. BIGNEY,
J. P. D. JOHN,
D. S. JORDAN,
STANLEY COULTER,
W. A. NOYES,
W. P. SHANNON,
T. C. MENDENHALL,
J. L. CAMPBELL,
J. C. ARTHUR,
JOHN M. COULTER,
O. P. HAY,
J. C. BRANNER,
JOHN S. WRIGHT.

CURATORS.

Botany	JOHN M. COULTER.
Ichthyology	CARL H. EIGENMANN.
Ornithology	AMOS W. BUTLER.
Herpetology	O. P. HAY.
Entomology	F. M. WEBSTER.
Mammalogy	E. R. QUICK.

COMMITTEES, 1894-95.

PROGRAMME.

P. S. Baker, G. W. Benton.

MEMBERSHIP.

R. E. Call, J. S. Wright, H. A. Huston.

NOMINATIONS.

J. C. Arthur, C. L. Mees, C. H. Eigenmann.

AUDITING.

W. E. Stone, L. M. Underwood.

STATE LIBRARY.

C. A. Waldo, W. A. Noyes, A. W. Butler, J. S. Wright, A. W. Duff.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

J. C. Arthur, J. M. Coulter, J. S. Wright.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, Ph. Kirsch.

EDITORS.

Stanley Coulter, R. Ellsworth Call, J. C. Arthur, A. Wilmer Duff.

BIOLOGICAL SURVEY.

L. M. Underwood, A. W. Butler, J. M. Coulter.

DIRECTORS BIOLOGICAL SURVEY.

L. M. Underwood, C. H. Eigenmann, V. F. Marsters.

CHANGE OF FORM OF ORGANIZATION OF THE ACADEMY WITH ITS RELATION TO THE STATE.

C. L. Mees, J. C. Arthur, T. C. Mendenhall.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, A. W. Butler, C. H. Eigenmann.

FINANCE.

C. H. Eigenmann, Stanley Coulter.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Treasurer.
1885-6	David S. Jordan.	Amos W. Butler.	. . . .	O. P. Jenkins.
1886-7	John M. Coulter.	Amos W. Butler.	. . . .	O. P. Jenkins.
1887-8	J. P. D. John.	Amos W. Butler.	. . . .	O. P. Jenkins.
1888-9	John C. Branner.	Amos W. Butler.	. . . .	O. P. Jenkins.
1889-90	T. C. Mendenhall.	Amos W. Butler.	. . . .	O. P. Jenkins.
1890-1	O. P. Hay.	Amos W. Butler.	. . . .	O. P. Jenkins.
1891-2	J. L. Campbell.	Amos W. Butler.	. . . .	C. A. Waldo.
1892-3	J. C. Arthur.	Amos W. Butler.	Stanley Coulter. W. W. Norman.	C. A. Waldo.
1893-4	W. A. Noyes.	C. A. Waldo.	W. W. Norman.	W. P. Shannon.
1894-5	A. W. Butler.	John S. Wright.	A. J. Bigney.	W. P. Shannon.

CONSTITUTION.

ARTICLE I.

SECTION 1. This Association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall

become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a president, vice-president, secretary, assistant secretary, and treasurer, who shall perform the duties usually pertaining to their respective offices, and in addition, with the ex-presidents of the Academy, shall constitute an executive committee. The president shall, at each annual meeting, appoint two members to be a committee which shall prepare the programmes and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis, within the week following Christmas of each year, unless otherwise ordered by the executive committee. There shall also be a summer meeting at such time and place as may be decided upon by the executive committee. Other meetings may be called at the discretion of the executive committee. The past presidents, together with the officers and executive committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.
2. The president shall deliver a public address on the evening of one of the days of the meeting at the expiration of his term of office.
3. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.
4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.
5. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.
6. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

HONORARY FELLOW.

[3]Daniel Kirkwood . . . . Riverside, Cal.

FELLOWS.

J. C. Arthur. . . . . Lafayette.
P. S. Baker . . . . Greencastle.
W. S. Blatchley . . . . Indianapolis.
J. C. Branner . . . . Palo Alto, Cal.
A. W. Butler . . . . Brookville.
R. E. Call. . . . . Cincinnati, O.
J. L. Campbell . . . . Crawfordsville.
John M. Coulter. . . . . Lake Forest, Ill.
Stanley Coulter . . . . Lafayette.
H. T. Eddy . . . . Minneapolis, Minn.
C. H. Eigenmann . . . . Bloomington.
W. F. M. Goss. Lafayette.
Thos. Gray . . . . Terre Haute.
O. P. Hay. . . . . Chicago, Ill.
H. A. Huston . . . . Lafayette.
J. P. D. John . . . . Greencastle.
D. S. Jordan . . . . Palo Alto, Cal.
V. F. Marsters . . . . Bloomington.
C. L. Mees . . . . Terre Haute.
T. C. Mendenhall . . . . Hoboken, N. J.
D. M. Mottier . . . . Bloomington.
W. W. Norman . . . . Austin, Texas.
W. A. Noyes . . . . Terre Haute.
J. T. Scovell . . . . Terre Haute.
W. P. Shannon . . . . Greensburg.
Alex. Smith. . . . . Chicago, Ill.
W. E. Stone. . . . . Lafayette.
M. B. Thomas. . . . . Crawfordsville.
L. M. Underwood . . . . Auburn, Ala.
T. C. Van Nuys . . . . Bloomington.
C. A. Waldo. Lafayette.
F. M. Webster. Wooster, O.
J. S. Wright . . . . Indianapolis.

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[3]Deceased.

NON-RESIDENT MEMBERS.

D. H. Campbell	Palo Alto, Cal.
B. W. Evermann	Washington, D. C.
Charles H. Gilbert	Palo Alto, Cal.
C. W. Green	Palo Alto, Cal.
C. W. Hargitt	Syracuse, N. Y.
Edward Hughes	Palo Alto, Cal.
O. P. Jenkins	Palo Alto, Cal.
J. S. Kingsley	Tufts College, Mass.
Alfred Springer	Cincinnati, O.
Robert B. Warder	Washington, D. C.

ACTIVE MEMBERS.

J. Alex. Adair	Hanover.
R. J. Aley	Bloomington.
Timothy H. Ball	Crown Point.
H. H. Ballard	Terre Haute.
C. L. Barnes	Indianapolis.
George W. Benton	Indianapolis.
A. W. Bitting	Lafayette.
Alexander Black	Greencastle.
Henry L. Bolley	Fargo, N. D.
M. A. Brannon	Ft. Wayne.
Charles C. Brown	Indianapolis.
W. V. Brown	Greencastle.
H. L. Bruner	Irvington.
Wm. Lowe Bryan	Bloomington.
J. B. Burris	Cloverdale.
Noble C. Butler	Indianapolis.
J. T. Campbell	Rockville.
J. Fred Clearwaters	Greencastle.
H. J. Clements	Washington.
U. O. Cox	Mankato, Minn.
M. E. Crowell	Indianapolis.
Will Cumback	Greensburg.
Alida M. Cunningham	Kirkpatrick.
George L. Curtiss	Greencastle.
B. M. Davis	Irvington.
D. W. Dennis	Richmond.
Chas. R. Dryer	Terre Haute.
A. Wilmer Duff	Lafayette.
Joseph Eastman	Indianapolis.

E. G. Eberhardt	Indianapolis.
M. N. Elrod	Hartsville.
F. L. Emory	Ithaca, N. Y.
Samuel G. Evans	Evansville.
E. M. Fisher	Lake Forest, Ill.
J. J. Flather	Lafayette.
A. L. Foley	Bloomington.
Robert G. Gillum	Indianapolis.
J. R. Francis	Indianapolis.
J. B. Garner	Crawfordsville.
G. F. Glick	Newbern.
Katherine E. Golden	Lafayette.
Michael J. Golden	Lafayette.
W. E. Goldsborough	Lafayette.
C. F. Goodwin	Brookville.
S. S. Gorby	Indianapolis.
Vernon Gould	Rochester.
E. H. Heacock	Leadville, Colo.
Edwin Stanton Hallett	Corydon.
A. S. Hathaway	Terre Haute.
Wm. Perry Hay	Irvington.
Franklin W. Hayes	Indianapolis.
Robert Hessler	Logansport.
T. H. Hibben	Indianapolis.
George C. Hubbard	Moore's Hill.
J. W. Hubbard	Bloomington.
Thomas M. Iden	Irvington.
Alex. Jameson	Indianapolis.
A. E. Jessup	Carmel.
Sylvester Johnson	Irvington.
W. B. Johnson	Franklin.
E. M. Kindle	Bloomington.
J. G. Kingsbury	Irvington.
W. H. Kirchner	Minneapolis, Minn.
Ph. Kirsch	Columbia City.
Charles T. Knipp	Bloomington
Daniel Layman	Indianapolis.
W. S. Lemen	Indianapolis.
Robert E. Lyons	Bloomington.
Herbert W. McBride	Chicago, Ill.
Robert Wesley McBride	Indianapolis.
Kate McCarthy	Wabash.
Rousseau McClellan	Indianapolis.
D. T. McDougal	Minneapolis, Minn.
F. M. McFarland	Palo Alto, Cal.
J. W. Marsee	Indianapolis.

W. J. Moenkhaus	Bloomington.
G. T. Moore	Crawfordsville.
Joseph Moore	Richmond.
Warren K. Moorehead	Columbus, Ohio.
J. P. Naylor	Greencastle.
Charles E. Newlin	Indianapolis.
E. W. Olive	Frankfort.
J. H. Oliver	Indianapolis
D. A. Owen	Franklin.
Elwood Pleas	Dunrieth.
A. H. Purdue	Chicago, Ill.
Ryland Ratliff	Fairmount.
D. C. Ridgley	Delphi.
George L. Roberts	Greensburg.
L. J. Rettger	Terre Haute.
Adolph Rogers	New Castle.
John F. Schnaible	Lafayette.
C. E. Schafer	Huntington.
Claude Siebenthal	Bloomington.
G. W. Sloan	Indianapolis.
Harold B. Smith	Lafayette.
F. P. Stauffer	Logansport.
M. C. Stevens	Lafayette.
Joseph Swain	Bloomington.
A. E. Swann	Indianapolis.
Geo. A. Talbert	Laporte.
Frank B. Taylor	Ft. Wayne.
Erastus Test	Lafayette.
F. C. Test	Washington, D. C.
Wm. M. Thrasher	Irvington.
A. L. Treadwell	Oxford, Ohio.
Joseph H. Tudor	Baltimore, Md.
E. B. Uline	Lake Forest, Ill.
A. B. Ulrey	Bloomington.
W. B. Van Gorder	Knightstown.
Ernest Walker	New Albany.
F. A. Walker	Anderson.
W. O. Wallace	Wabash.
M. W. Wells	Indianapolis.
Wm. M. Whitten	South Bend.
J. R. Wiest	Richmond.
H. W. Wiley	Washington, D. C.

W. L. Wood	Covington.
A. J. Woolman	Duluth, Minn.

Honorary fellow	1
Fellows	33
Non-resident members	10
Active members	121
Total	165

TENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The tenth annual meeting of the Indiana Academy of Science was held in Indianapolis, December 27 and 28, 1894, preceded by a session of the Executive Committee of the Academy, 8 P. M., December 26.

The Academy met in general session, 9 A. M., December 27, at which committees were appointed and various other business transacted, after which there was an adjournment until 2 P. M., whereupon it met in two sections—biological and physico-chemical—for the reading and discussion of papers. After adjournment of the sectional meetings, at 5 P. M., the Academy again met in general session at 7 P. M., for the address of the retiring President, Prof. W. A. Noyes, subject, "Lavoisier."

December 28, 9 A. M., the Academy met in general session for the transaction of business, after which followed the reading and discussion of papers until adjournment at 1 P. M.

After the adjournment of the Academy the Executive Committee met with a committee of the Science Club of Indianapolis to discuss the publication of the proceedings of the Academy by the State.

FIELD MEETING OF 1895.

The 1895 Field Meeting of the Indiana Academy of Science was held at Wyandotte Cave May 15, 16 and 17. The business session of the meeting was held at 8 P. M., May 15. In the absence of the President and the Vice-President, Dr. P. S. Baker acted as chairman. The remaining time of the meeting was spent in the field.

WINTER MEETING.

INDIANAPOLIS, DECEMBER 27 and 28, 1894.

PRESIDENT'S ADDRESS.

LAVOISIER.

BY W. A. NOYES.

On May 8, of this year was the centennial of the execution of a man who influenced profoundly the development of scientific knowledge. To Antoine Laurent Lavoisier belongs chiefly the honor of the saying that "Chemistry is a French science," a saying which possesses a certain amount of truth, though it does injustice to much good work done elsewhere, and is entirely false as regards the present condition of the science.

During many centuries, such workers in chemistry as there were followed mostly a vain search after gold and after the elixir of life. During this period of sordid aim many facts were discovered, but little real progress was made, for facts do not constitute a science. Then, for another century, chemistry was pursued mainly in connection with the study of medicine with the thought that the science would hold in its grasp the secret of all disease and its cure. During this period, too, there was some progress, for the aim was a little less sordid and base, and somewhat more rational means were used, but the chemistry of that day, very much like a good deal of the medical science even of to-day, labored under the difficulty of being an applied science without any satisfactory foundation in pure science. As in all such cases, the science was constantly confronted with the necessity of doing something immediately, when it had nothing but the crudest empiricism to guide it. The best deductions which were possible were made from a few and very imperfect data, and the conclusions were very often in error. Often years, or even centuries of experience are required for the discovery, by such methods, of the right course of procedure, which may, later, be known as a simple corollary from a single principle of pure science.

Pure science belongs to all time, and can wait for a fact or a principle till the time is ripe for its discovery. Applied science is essentially ephemeral, and must have *to-day* the best it can get. If it can not find certain knowledge it must guess to the best of its ability. And so it follows that only those forms of applied science which follow in lines of pure science make great and lasting progress.

Nowhere has this been more clearly evident than in the development of chemistry. Medicine, during the era of medical chemistry, probably killed more of its patients than it cured, and the applied chemistry of to-day makes greater advances in a decade than were made during whole centuries of empiricism.

It is scarcely more than two centuries since a few men first began to search into the composition of bodies with the pure, high aim of an endeavor to extend human knowledge. From this period dates the beginning of chemistry as a pure science, and in this sense those who refer the beginning of chemistry to Lavoisier do injustice to such men as Boyle, Stahl, Black, Scheele, Priestly, Cavendish and many others.

These men worked with the same spirit and purpose, and often in the face of far greater difficulties than those which later workers were compelled to face. These were the real pioneers of pure chemistry.

In the hands of these workers we find for the first time in the science one of the best and highest characteristics of any pure science, the proposal, development and general acceptance of an important theory—a theory which coördinated and explained from one point of view many and diverse phenomena—a theory conceived in a pure philosophical spirit—one step in the constant endeavor of the highest minds to tear away from before our eyes the things which are fortuitous and misleading and to get a little closer to the realities which lie at the basis of all material existence. I refer, of course, to the theory of phlogiston.

In outward appearance ordinary combustion is of the nature of a decomposition and this view of the phenomena was held from the earliest times. Building, as every founder of a theory must, on the best knowledge which was possessed, and recognizing the close connection between the oxidation of metals and ordinary combustion the chemists of this time proposed the theory that all bodies capable of combustion or oxidation contain a common substance or principle called phlogiston, and that combustion consists in the escape of the phlogiston leaving behind that with which it was combined.

In accordance with this view, wood, charcoal and similar substances are rich in phlogiston and mostly disappear in burning. Metals are composed of phlogiston and the metallic calcx or what we now know as the oxide—the metal being considered compound and the oxide as one of its parts.

At the time when the theory was proposed and developed it gave a quite satisfactory explanation of most of the phenomena then known. It served as a means of bringing together under one point of view very many and diverse facts and of coördinating them all under a system which was clear and intelligible. As new facts were discovered they were explained and systematized as far as possible in

accordance with the theory. And so it happened that, while the theory contained only a partial truth, and even that half-truth was so badly distorted that we have some difficulty even now in recognizing it, the development of the science was comparatively rapid during this period. And we may be sure that this theory furnishes one important reason why chemistry made more progress during the century of its proposal, development and general acceptance than during many centuries before. But, as often happens, a theory which was extremely valuable for a time and which was probably the best which the science of its day was capable of accepting, outlived its usefulness and was generally believed after the facts necessary for its overthrow had been discovered. At such times there comes the necessity for a man with a profound reverence for facts as of supreme importance and as beyond and underlying all theories—a man, too, with great power to see through all external phenomena and grasp their true explanation in spite of any preconceived notion or any theory no matter how generally accepted. I think it not without significance that the man who could do all this for chemistry was produced in France during that period before the revolution when the country was full of the fermentation of those ideas which led to that tremendous revolt against all forms of dogmatism and authority when men were ready to question ideas and beliefs which had been held sacred for centuries and when the feeling was prevalent that all knowledge and even all forms of society must be torn down and rebuilt from the very foundations.

Lavoisier was a fit product of such an age– a man capable of proposing a heresy in the face of all orthodox scientists and with the ability, too, to prove, in the end, that his heresy was true and orthodoxy was false.

Lavoisier was born in 1743. His father was a wealthy merchant, who was, himself, interested in science, and personally acquainted with some of the most noted scientific men of Paris. The son received a thorough education under the best teachers of the city. He seems to have been especially interested in mathematics and chemistry, but studied carefully other sciences as well. He was first known to the scientific world through his competing, when 21 years old, for a prize offered by the French government for the best method of lighting a great city. The prize of two thousand livres was awarded to Lavoisier, but he caused the money to be divided between three of his competitors to repay them for their outlay in making experiments. He received, however, through the French Academy, a medal granted him by the king in recognition of his services, and it was largely in consideration of this work that he was chosen a member of the Academy at the early age of twenty-five. While Lavoisier devoted most of his time and energy to the prosecution of researches in pure science he seems always

to have retained a lively interest in technical applications of scientific knowledge, and often rendered valuable services to his country in such matters. For a long time he had oversight of the manufacture of saltpeter and gunpowder for the French government, and it is remarked that during this period the gunpowder of France was the best in the world, while after his death it became much inferior. We can scarcely find a better answer to those who would have us think that an interest in technical applications is beneath the dignity of those who are devoted to the development of the higher departments of science. We find, on the contrary, that scientific men of the very highest rank have shown great interest in the material advantages which would result from their discoveries and have frequently taken time for the careful study of technical problems. While the absorbing consideration of material results, which is required of those who are engaged in technical pursuits, is undoubtedly incompatible with any high scientific attainment, I believe that the scientist who occasionally studies carefully and thoroughly some technical application of his science will find that his mental horizon has been broadened by the process. We have too many men nowadays who are so absorbed in some narrow corner of their science as to lose all breadth of view and all true sense of relative value and importance in scientific work, and who become one-sided and seriously dwarfed in character. It is, after all, important that one should be a man, and retain broad human interests as well as that he should attain high rank as a scientist.

In speaking of Lavoisier's work in pure science I shall not attempt an exhaustive catalogue of his researches, for it is not my purpose to give a history of his life, but rather, if possible, to gain a clear conception of his character and his work and of the relation which these bear to the development of the science of chemistry.

The first work in which we can see some clear relation to his later achievements was published in the memoirs of the Paris Academy for 1770. It concerned the conversion of water into earth. The mere fact that such a topic should require careful experiment and serious discussion gives us a glimpse of how very radically different from ours was the opinion of the best science of that day upon such fundamental subjects as the indestructibility and interconvertibility of matter. From the earliest times it had been believed that water may, under various conditions, be converted into earth. In later times it was thought that this view had been confirmed by the work of many careful experimenters. Glass vessels were almost universally used for the distillation and evaporation of water, and many different observers found that even water which had been repeatedly distilled left behind, on evaporation, small amounts of earthy matter

which were thought to have been formed by the section of heat upon the water. To test the matter Lavoisier placed some water in a sealed vessel so arranged that the water could be boiled in the lower part, while the steam would condense above and run back. He kept three pounds of water boiling in this way for more than three months. At the end of the time he evaporated the water and obtained from it 20.4 grains of earthy matter, while the vessel used had lost 17.4 grains in weight. The difference he considered as due to unavoidable errors of experiment, and from the imperfect data he drew the correct conclusion that water can not be changed into earth. Such results as these must have given to Lavoisier the feeling that he could not trust the observations of other chemists, but must test every experimental fact for himself. This attitude, which was, undoubtedly, not without some reason, is closely connected with one of the worst sides of his character—a tendency to belittle the work of others, and even to appropriate as his own discoveries made by others. We find that Lavoisier repeatedly described discoveries which had been made by some one else in such a manner as to give the impression that the discovery had been made by himself. It is true that in some cases the discovery acquired in his hands an entirely different meaning. This is especially true of the discoveries of oxygen and of the composition of water. Lavoisier was, undoubtedly, the first to see the true significance and importance of these discoveries, and the very great value of the discoveries to the scientific world depends far more on the labors of Lavoisier than on those of Priestley and Cavendish. Yet this can not lead us to condone the desire which was shown of appropriating for himself the honor which belonged to others. Indeed, we can not but feel that such conduct is more than usually reprehensible in one whose own work was really so very great and who, of all men, had so little need to seek for honor that was not entirely his own. There was certainly something lacking in the moral fiber of the man which detracts very much from our opinion of his personal character however much we admire his scientific achievements.

Lavoisier's study of the conversion of water into earth was of especial interest because of the way in which he attacked the problem. Previous to his time very few chemists paid any attention to quantitative relations in chemical phenomena, and his use of the balances in studying the question proved in his hands the beginning of a new era. Too much has often been made, however, of this distinction between the chemistry of the era of phlogiston and that which immediately followed the downfall of that theory. Cavendish spent a great deal of time on quantitative experiments, and many of his results exceeded in accuracy those of Lavoisier, yet all of his work was conceived and his results were interpreted in terms of the theory of phlogiston. Methods of quantitative analysis similar to

those still in use were developed by Bergmann and by other contemporaries of Lavoisier who still held entirely to the old theories. The quantitative method was "in the air" as it were, and was coming into more and more extended use in the hands of many different chemists. And, even after Lavoisier's views were generally accepted, quantitative results were usually very inaccurate till some time after Dalton's atomic theory had given a sharp means of control. Lavoisier's greatness was not so much in the introduction of a new method, as in that wonderful insight which enabled him to see through the appearances on the surface and find the real reasons which lay beneath.

The beginning of his most valuable work seems to have been made in 1772, when he was not yet thirty years of age. In a short note written at this time and published in 1773, he states that the oxidation of metals and also the combustion of phosphorus and sulphur is accompanied by an increase of weight and by the absorption of a large amount of air, also that on the reduction of metallic oxides a large amount of gas, or "air" is evolved. In these crude and imperfect statements, we see the germ of all his greatest discoveries. In 1774 he described more accurately his experiments with tin. He placed the metal in a retort, sealed it hermetically and weighed the whole. He then heated the retort till the tin was oxidized, and then weighed the whole again, showing that there was no change in weight. On opening the retort, air entered, and there was an increase of weight which he says was exactly equal to the gain in weight of the tin due to oxidation. We know that this could not have been strictly accurate, for oxygen had been absorbed, and air, which is specifically lighter than oxygen, had entered, but we see once more the great power which the man had of drawing correct conclusions from imperfect data. A chemist of some standing has recently said, "that it is not the province of science to explain anything," and "that the business of science is to *describe* phenomena in a simple manner, to seek actual relations between measureable quantities, to deal only with things which can be handled and measured."[1] How erroneous and imperfect such a view of the province of science is, was never better illustrated than in the present case. Essentially the same fact in almost all of its details had been observed by Boyle one hundred years before, and many others had observed that metals increase in weight when oxidized. The fact alone was barren, the fact in conjunction with its correct explanation became fruitful in wonderful scientific developments.

In these first experiments Lavoisier does not seem to have recognized but what air, as a whole, was absorbed in processes of oxidation and combustion. On August 1, 1774, Priestley, in England, discovered oxygen gas, and visiting Paris

1. J. E. Trevor, Jr., Am. Chem. Soc., *16*, 520.

soon after, he described his discovery to Lavoisier. Priestley, with the other chemists of his time, held to the theory of phlogiston, and expressed his discovery in terms of that theory. In accordance with that theory he called oxygen dephlogisticated air, and nitrogen, or in general, air which had lost the power of supporting combustion, whether pure nitrogen or not, phlogisticated air. The thought conveyed by these terms was that air possessed a certain capacity for absorbing the phlogiston which was supposed to be given off during combustion, but that ordinary air already contained a considerable amount of phlogiston. If this phlogiston were removed the capacity to take it up again would, of course, be increased, and the resulting substance which we call oxygen could properly be called dephlogisticated air, while nitrogen, which was supposed to have taken up all the phlogiston which it could hold, was called phlogisticated air. It is evident, at once, that while the honor of the discovery of oxygen really belongs to Priestley, the new substance was not to him a separate and distinct element in any such sense as we now understand it, but was rather a sort of modified air. The theory of phlogiston dealt chiefly with outward appearances and qualitative phenomena, and the time had now come when the theory was inadequate and a hindrance to further progress. Lavoisier seems to have been the only chemist of the time who recognized this. After Priestley had told him of his discovery he repeated the experiments for himself, and soon came to a comparatively clear and correct view of the composition of air, and the real nature of oxidation and combustion. But while even at this early date he must have begun to see that the theory of phlogiston was unnecessary, and probably fallacious, his open conflict with the theory does not seem to have begun till several years later. He contented himself with a description of his experiments and explanation of his results, rather ignoring than directly combatting the prevailing theory. He had acquired reputation by this time as a careful experimenter and as one thoroughly acquainted with the history and theories of his science. He was recognized, therefore, when the time came, as one competent to criticise current theories, and as one whose criticism must, at least, receive respectful attention.

During the ten years that followed, from 1775 to 1785, Lavoisier busied himself almost exclusively with experiments more or less closely connected with combustion and oxidation. Gradually he proved, by careful experiments made with a great number of different substances, that ordinary combustion consists in all cases of a combination with oxygen. He showed that "fixed air" is formed by the combustion of the diamond and of charcoal; that phosphoric acid, according to the nomenclature of the period which followed, is formed by the combustion of phosphorus, and also by its oxidation with nitric acid; that both sulphurous

and sulphuric acids are compounds of sulphur with oxygen, and that "fixed air" is also formed by the combustion of candles and of other organic matter. These experiments led him to not only clear and correct views of the phenomena of combustion and oxidation, but they also gave rise to a radically new conception of the nature of acids and salts. The opinions which he developed were afterwards found to be imperfect, but they were a very great advance on anything which had preceded, and were of incalculable value in the development of chemical science. After finding from his own experiments and those of others that oxygen is a common constituent of carbonic, phosphoric, sulphurous, sulphuric and nitric acids he made the generalization that oxygen is the source of all acid properties, and called it by its present name, which means "acid former." To him an acid was simply a compound of carbon, sulphur, or some other element with oxygen, and a salt was a compound of such an oxide with an oxide of a metal. This view held practical sway in chemistry for sixty years, and is at the basis of many expressions which chemists still use. While doubtless less perfect than the view which considers acids as compounds of hydrogen, it nevertheless expressed clearly some truths which our modern chemistry does not quite so clearly express, for oxygen is still, as always, a great acid-forming principle, and salts contain metals as well as non-metals in an oxidized form. Lavoisier considered that the combination of a metal with an acid may take place in two ways. Either the metal combines with a part of the oxygen of its acid forming an oxide which then combines with the acid, or as we should say, with the anhydride of the acid; or the metal, by the aid of the acid, decomposes the water present, combining with its oxygen and liberating its hydrogen, and the oxide formed there combines with the acid. The first view may still be considered as essentially correct as an explanation of such cases as the action of concentrated sulphuric acid on copper; here copper oxide is undoubtedly formed, for some of it escapes combination with the acid, and sulphur tri-oxide is present as an independent compound at the temperature of the reaction, and very probably combines with the copper oxide as it is formed, to produce copper sulphate. As regards the second view, which applies to such cases as the solution of zinc in dilute sulphuric acid, there is still some diversity of opinion and some uncertainty in the minds of chemists. The common statement of our text-books is that the action consists in a substitution of the metal for the hydrogen of the acid, and this is undoubtedly correct, as a superficial view of the matter. The explanation which has been more recently proposed, however, and which has already gained many adherents, is that direct substitution takes place in such cases with very great difficulty, if at all, and that action takes place readily only when the acid has been dissociated into

its ions, and that the real action consists in the exchange of charges of electricity between atoms of hydrogen and atoms of the metal, the atoms of the metal, with their newly acquired charge, becoming ions in the solution. Whatever may be the truth of the matter, the views of Lavoisier were of very great value in the development of chemistry. They contributed to a clearer conception of the nature of salts, and they laid the foundation for a rational nomenclature, which was introduced for the first time in connection with Lavoisier's system, though the principles of the nomenclature seem to have been proposed by De Morveau, and Berthollet and Fourcroy aided Lavoisier in their development.

Beside the theories of combustion and oxidation and of the relations of acids, oxides and salts, which must be considered as his greatest contribution to science, Lavoisier worked successfully in a number of other directions. He paid close attention to the heat relations involved in combustion; he studied carefully the alcoholic fermentation and gained a very close and correct conception of the process and made some attempts to determine the quantitative composition of organic bodies. These attempts were not very successful, but the methods used were correct in principle and laid the foundation for the better work which was done years afterwards. In the domain of physiological chemistry and in physics Lavoisier also did some excellent work.

His literary activity consisted chiefly in the preparation of papers describing his work. No less than sixty communications of this kind were published in the Memoirs of the Paris Academy from 1768 to 1787. Not till toward the close of his life did he gather the results of his work together in a systematic treatise on chemistry, which appeared in 1789. I can not refrain from quoting two extracts from this book, which give us a glimpse of the character of the man and show us something of the secret of his wonderful power. The first is from his preface.

After calling attention to the fact that in every day affairs our mistakes are constantly checked and corrected by the unpleasant effects which follow them, he goes on to say:

"In the study and practice of the sciences it is quite different; the false judgments we form neither affect our existence or our welfare and we are not forced by any physical necessity to correct them. Imagination, on the contrary, which is ever wandering beyond the bounds of truth, joined to self-love and that self-confidence we are so apt to indulge, prompt us to draw conclusions which are not immediately derived from facts; so that we become in some measure interested in deceiving ourselves. Hence it is by no means to be wondered that in the science of physics in general men have often made suppositions instead of forming conclusions. Those suppositions, handed down fromone age to another, acquire

additional weight from the authorities by which they are supported, till at last they are received, even by men of genius, as fundamental truths.

"The only method of preventing such errors from taking place, and of correcting them when formed, is to restrain and simplify our reasoning as much as possible. This depends only on ourselves, and the neglect of it is the only source of our mistakes. We must trust to nothing but facts; these are presented to us by nature and can not deceive. We ought, in every instance, to submit our reasoning to the test of experiment, and never to search for truth but by the natural road of experiment and observation. Thus mathematicians obtain the solution of a problem by the mere arrangement of data, and by reducing their reasoning to such simple steps, to conclusions so very obvious, as never to lose sight of the evidence which guides them.

"Thoroughly convinced of these truths, I have imposed upon myself as a law never to advance but from what is known to what is unknown; never to form any conclusion which is not an immediate consequence necessarily flowing from observation and experiment; and always to arrange the facts, and the conclusions drawn from them in such an order as shall render it most easy for beginners in the study of chemistry thoroughly to understand them. Hence I have been obliged to depart from the usual order of courses of lectures and of treatises on chemistry, which always assumes the first principles of the science, as known, when the pupil or the reader should never be supposed to know them till they have been explained in subsequent lessons. In almost every instance these begin by treating of the elements of matter, and by explaining the table of affinities, without considering that, in so doing, they must bring the principal phenomena of chemistry into view at the very outset; they make use of terms which have not been defined and suppose the science to be understood by the very persons they are only beginning to teach. It ought likewise to be considered, that very little of chemistry can be learned in a first course, which is hardly sufficient to make the language of the science familiar to the ears, or the apparatus familiar to the eyes. It is almost impossible to become a chemist in less than three or four years of constant application."

These statements are no less true to-day than one hundred years ago. No less apposite is the following, referring to the work to be done in chemistry:

"This is a vast field for employing the zeal and abilities of young chemists, whom I would advise to endeavor rather to do well than to do much. * * * * Every edifice which is intended to resist the ravages of time should be built on a sure foundation; and, in the present state of chemistry, to attempt discoveries by

experiments, either not perfectly exact, or not sufficiently rigorous, will serve only to interrupt its progress, instead of contributing to its advancement."

During the stormy days of the Revolution, as well as before, Lavoisier rendered frequent services to his country. In 1787 he was elected to the Provincial Assembly of Orleans. In 1790 he was a member of the commission which devised the metric system of weights and measures. In 1791 as a member of a commission he published an essay on the National Resources of France, which entitles him to high rank as a political economist. These facts show that he was a man of broad interests as well as a chemist of preëminent rank.

Some of his public acts, and especially those in connection with the collection of taxes rendered it easy to find some trivial complaint against him. And during the reign of terror, while the power of Robespierre was at its height, a trivial complaint was equivalent to condemnation. After sentence he asked for a fortnight's delay that he might complete some scientific experiments, but with the words "We have no more need of philosophers," he was hurried to execution. So died, on May 8, 1794, the greatest chemist of the eighteenth century. I had almost said of any century. For we can scarcely find in the history of thought another who has so transformed the science with which he worked. He cleared away the misconceptions and erroneous speculations of centuries and, building on a solid basis of experimental facts, he laid a sure foundation for rapid and permanent growth in chemical knowledge.

PAPERS READ.

Some Factors in the Distribution of Gleditschia Triacanthos, and Other Trees. By Ernest Walker.

The importance of winds as factors in the distribution of plants has always been recognized by all who have written on subjects connected with plant-geography. It seems, however, that their effectiveness has been appreciated only in the case of extremely fine and light seed, or those provided with appendages for suspension in air, while in the case of heavier seeds, unprovided with such appendages, they are held even by many of our most authoritative writers to be of little or no consequence. Such seeds are thought to be too heavy to be affected in the least by any wind short of a "violent storm" or real "hurricane." As these are only

occasional, and as the direction of winds is thought to be so variable, it has become customary to speak of them as among the "occasional" or "accidental" factors in plant migrations.

Darwin objected to the term "accidental," and for the best of reasons, suggesting as a substitute the word "occasional." But to the writer it seems that the second term, while not quite as unscientific as the former, is in other respects no improvement. For even if the influence of winds in seed diffusion were limited to the lighter or appendaged seeds, it would still be objectionable, as must be obvious.

By no means, however, are we justified in holding that winds affect only lighter seeds, and that moderate winds have little or no influence on heavier fruits and seeds, which any one may readily demonstrate for himself by observation. The writer shared in the prevailing opinion until observations convinced him of the contrary, and showed that ordinary winds have sufficient force to transport even the heavier fruits and seeds, when borne on parts some distance above the ground, to considerable distances. In considering the value of winds as plant diffusing agents, several incidentals occur more or less influencing their effectiveness, which it may be well to mention.

As is obvious, height of the plant is an important factor. Were a fruit as large as the cocoa-nut to be borne on a low plant close to the ground, winds could have no appreciable effect on its fall; but growing as it does, on a tall tree, the strong winds, such as are common in the regions it inhabits, may drive the fruit in falling considerably from the perpendicular before it has reached the ground. Again, tall plants are likely to travel more directly with winds in regions where these blow mainly from one direction during the fruiting season, owing to the fact that the direction of the wind is less affected by irregularities of land surface at some distance above the ground.

Rigidity of trunks and branches is an item worth considering. Flexible stems and branches will lean with the wind, and drop their fruit farther on the side from the wind than in the case of more rigid ones.

Weight, bulk and form of fruits have their values. Lighter unappendaged fruits and seeds may be carried a considerable distance by winds, even when produced upon low growing plants. Where the bulk of surrounding parts is large in proportion to the size of the seeds, it not only makes the force of wind more effective, but in some instances it is probable these bulky parts by their decay enrich the spot upon which the fruit finally rests, and thus helps in giving the young seedlings a start in life, and in traveling across infertile belts.

Peculiarities in form may enable the winds to drive some fruits before them even after the latter have fallen to the ground. The light, globular form of some pine cones when dried enable them to roll readily. In the case of other forms, the curvature of cylindrical cones or slight hooks at the tip of the scales tend to check motion due to gravity, or the influence of winds. Curvature or twisting in flat fruits is obviously an advantage in traveling before winds.

The time and duration of the fruiting season is a matter of the utmost importance; especially if what the writer shall suggest in regard to the direction of winds for certain regions and seasons shall be found to be true. Plants which fruit throughout the season would tend to spread in all directions, while those that ripen their fruit in a single crop at a stated season would be inclined to travel more in one or a few directions, and occupy particular ranges. Darlington always mentions the fruiting season; later authors but rarely, which the writer has often had occasion to regret.

Dehiscence of fruits may have an important bearing in the matter of seed dissemination. The forceful and sudden discharge of seeds in oxalis and violets makes these plants independent of outside help, and scatters the seed in all directions. In these cases the seed are discharged slightly upward as well as outward, enabling these plants to ascend, in time, even steep slopes. In violets cleistogamous flowers extend the fruiting season through even the hot months of summer. These fruits are produced for the most part under ground, and were they to remain there, would be of no value in spreading the species; but after ripe the stalk of the pod elongates and elevates the fruit during dehiscence, and the seeds are scattered as in the case of the pods of the ordinary flowers.

In *Œnothera biennis* the pods are only partially dehiscent at the top, and remain upright on the plant. The top of the plant bends with, and is shaken about by, winds. The seeds are thus scattered about during a considerable interval of time. This brings up the important point relating to the duration of the period seeds and fruits are carried or retained on the plant after their maturity. When long, it increases the chances of many of the fruits being carried to considerable distances by winds: it has relation to the direction of travel or dissemination, and may have an important bearing on the distribution or the range of some appendaged seeds which ordinarily would be thought to travel with the caprice of the lightest wind.

Liatris squarrosa affords an illustration. In this plant the heavily plumed achenes are carried on the dry receptacle till far toward January. So the distribution of the seeds of this and some other species of *Compositæ* is brought about

by the prevailing fall and winter winds. Thus it is probable that the dissemination of even light appendaged seeds is not always as hap-hazard as is sometimes supposed.

The appendages and lightness, or minuteness of many seeds, is commonly thought to have relation only to a wide distribution of the species. But the character also has relation to habitat. Some such plants, as the cat-tail flag, *Typha latifolia*, grow only in particular places. Their habitat, as it were, is divided up into small portions and scattered all over the country. Their downy seeds are necessary mainly on this account. The seeds of such plants are scattered far and wide, floating away on the lightest breeze. Only those grow that find proper homes. This is true of the appendaged seeds of some trees, which grow mainly in certain situations, as in the case of those confined chiefly to water courses. Streams are supposed to carry such seeds and be the main agents in their distribution. This is said to be the case with most of the forest trees of Indiana. The writer believes, however, that the reason so many trees are found along water courses, is not because the streams have borne the seeds along, but because the seed germinate better in the fertile and waste conditions found along their borders. Many such trees have winged or downy seeds and are carried far across extensive regions. Many, and most of the seed fall over the dry belts between streams, but not finding the suitable conditions, never germinate. Those, however, that lodge along the streams, spring up.

The importance of winds as factors in plant distribution, and the truth of some of the statements already made, will be rendered clearer, however, by an account of some observations which the writer has made in relation to the influence of winds in scattering the fruits of the *Liquidamber* and *Gleditschia triacanthos*.

It is now twelve years since first the writer noticed near New Albany, Ind., an old gum tree standing alone on a slight elevat on in an old neglected field. The tree was an old one, with a trunk some 24 inches in diameter, but owing to its exposure, and the poverty of the soil, its crown had not penetrated farther heavenward than 40 feet; nor was the expanse of soil shaded by its branches above 30 feet in diameter. While making a list of the plants growing under and about the tree, it occurred to notice what became of the tree's own balls and seeds. The seeding gums springing up here and there around their parent then began to receive attention.

It was noticed that while seedlings of various ages grew in all directions around the old tree, they extended farther to the northeast than in other directions. Measurements followed. To the west and south 50 feet covered the

distance between the trunk and the farthest seedling. On the northeast, however, numbers of these reached as far as 200 feet; some 250 feet, and one 300 feet.

Three or four years ago the old tree was cut down and the field cleared of weeds, etc., and plowed up. The part of the field north-eastward from the tree was not molested, however. So the young grove of gums, which nature planted, is still growing. It is evident that the prevailing strong winds for the fall months during the years in which these young gums were planted, came principally from the southwest.

Since that time gum trees in other places around New Albany have been noticed similarily situated and in open woods. Their story has been the same. The same tendency has also been observed in seedlings of *Robinia Pseudacacia.*

Still further observations made during the past two seasons in the fruits and seedlings of the honey-locust afford additional proof of the power of ordinary strong winds to carry even heavy fruits to a considerable distance, and show that for the fall months and fruiting season of this tree the prevailing strong winds are from the southwest.

The honey-locust in question stands alone on the top of a broad, low hill, which, with the exception of the "knobs," is probably the highest point around New Albany. The soil of the hill is clothed with thin grass; is poor, being clayey on top, with fine, clayey sand beneath. The tree is a handsome one, with a trunk some twenty inches in diameter, and a broad, rounded head reaching upward forty feet, with a like spread.

In September, 1893, it was noticed that there was an enormous crop of seeds. Many of them hung on the branches until toward December. In that month the spot was visited for the purpose of making observations. The pods lay thickly on the ground; and again they were found extending principally toward the northeast. Many were under the tree extending on the south, southeast and southwest, some twenty feet beyond the branches. On the northeast, however, they reached as far as 100 feet. I looked for seedlings. There were a number of various ages. A few were found about the tree on all sides. But the great proportion were northeastward. At a distance of 112 feet there was a small thicket of seedlings two and three years old. On the north some were found at 102 feet; on the northwest 41½ feet, west 39 feet, southwest 50 feet, east 76 feet.

The past summer has been one of the dryest in many years. In September the same tree was again full of pods. At this time new young seedlings four and five inches high were found growing about the tree by the hundred, seeming to indicate that a dry season is favorable to young seedlings of this tree. On the west, south and east these seedlings were numerous within thirty feet of the trunk.

Beyond this they were few and scattering, except on the northeast, where they were found at considerable distances. Owing to the difficulty of finding the young seedlings in the grass, measurements were not undertaken.

These items are full of significance. It is a very noticeable fact, and has often been remarked, that many of the plants of the North American flora have a northeasterly range. This is true of quite a list of heavy-fruited trees which ripen their fruit in the fall. Our observations show that ordinary strong winds, such as are common at the time the fruit of such trees is ripe, are capable of carrying it to a considerable distance, and that the winds carry the fruit, for some localities, farthest in the same direction year after year. The principal range of the gum, honey-locust, common locust and a number of other trees with more or less heavy fruits, and especially those of southern affinities, is from the southwest toward the northeast. This, coupled with the writer's observations, seems to indicate that for the broad belt of country extending from Texas and Missouri northeastward to Western New York and Pennsylvania, the strong winds of the fall months blow chiefly from the southwest. If this be shown by the records of meteorology to actually be the case, the northeastward tendency so noticeable in many of our plants will have been satisfactorily explained. The investigation of this matter is not full enough yet to warrant the definite statement. An examination of the Signal Service Records for a number of successive years will be necessary to settle the point. Reports for 1882-3 giving the weather tables for 1881-2 are all that have been examined. These bear out the suggestions made concerning the direction of the stronger autumn winds for the region mentioned. They show that these winds come chiefly from the southwest, and less frequently from the south and west. They also confirm (as far as they go) the opinion which had begun to spring up concerning other regions.

It is noticed that some of these heavy fruited trees and plants, instead of extending from the southwest northeastward, seem to be of northern relationship, and extend from the northwest portion of the country, mainly eastward from Dakota, across the great Lake Region to New England and Canada; or, again, from Dakota and Minnesota southeastward to Indiana and Kentucky, then northeastward to New England. This seems to indicate stronger west or northwest winds for the late summer or fall months in the northwest. In the case of those plants which come southeastward to Indiana, the winds would be from the northwest. In Indiana they would enter the belt in which southwest winds prevail in fall and be carried northeastward.

There are other regions in which the characteristic range of certain plants is in other directions. When fully investigated, the writer is inclined to think that

it will be found that, in the majority of land-plants with heavy fruits produced at a less or greater distance above the ground, winds prevailing at the time the fruit is ripe, more than any other factor, determine the direction of their range. The slender investigation of meteorological tables so far made is in harmony with these suggestions, but the whole truth remains yet to be ascertained.

Botanists have often commented on the remarkable difference between the flora of the California coast and that of the Atlantic States; and the strange resemblances of our eastern flora to that of eastern Asia. There is a long list of trees, for instance, of similar or identical species common to east Asia and the eastern States of America, including representatives of the genera in which are found magnolias, lindens, sumacs, buckeyes, box-elder, yellow wood, honey-locust, pear, shad-bush, dog-woods, rhododendrons, holly, persimmon, catalpa, sassafras, osage-orange, planera, walnut, butternut, hazelnut, birch, alder, yellow and white pine, hemlock, arbor vitæ, bald cypress and yews.

Looking over this list, it is noticeable that most of them are trees with heavy fruits ripe in the fall; and have, for the most part, in the United States (in general) a northeasterly range. Many of them are of southern affinities, and some northern.

Now, as plants are known to be delicate indicators of climatic conditions, and as it is fair to suppose the same or identical species will always behave the same way under the same conditions, if we find them behaving in a certain manner in two different places or parts of the world, the logical inference is that the conditions of the two regions are the same, or approximately so. Again, knowing the conditions in the two places to be practically the same, and the plants common to the two regions, acting the same, we naturally conclude that the same forces are operating in the same manner in both places. Following this out. we see that the truth in regard to the influence of winds in shaping the range of some of our American trees having been ascertained, bids fair to throw some light on the similarity between our eastern flora and that of eastern Asia, and explain how similar species in the two continents came to occupy like portions of their respective homes.

PROPAGATION AND PROTECTION OF GAME AND FISH. BY I. W. SHARP.

ANTHROPOLOGY: THE STUDY OF MAN. BY AMOS W. BUTLER.

A New Biological Station and its Aim. By C. H. Eigenmann.

One of the most promising fields for biological research is variation. Variation not only in the adult individuals, but in every step of the ontogeny. Descriptive zoölogy, as far as the higher groups are concerned, is well nigh exhausted. The general distribution of most of the vertebrates of North America is fairly well known, and it remains but to fill in details. Closely allied to variation is heredity. To these two subjects much of the energy that has hitherto been devoted to systematic zoölogy may be profitably diverted. The subject of variation or method of evolution is not a new one. I want to propose a new method of studying this subject.

During the coming summer a new biological station will be established somewhere in Indiana, whose chief aim will be the survey of a base-line for future studies in variation. A limited and well defined area, such as is to be found in one of the smaller lakes of Northern Indiana, will be selected, and the animals, chiefly non-migratory vertebrates of such a limited area, will be studied in detail for a series of years, if necessary. This survey will serve as the base-line for the study of variation of the same animals in the other localities. For economic reasons the fishes and reptiles will receive most of our attention.

An attempt will be made to determine the kind of variation, continuous or discontinuous, and the limits of variation. These limits should be examined for a series of years, or at definite longer intervals to note the annual, or biennial, or triennial, etc., variations, if any, from a given mean. The study conducted in this way ought to demonstrate the methods of evolution. A most interesting part of the work will be the variation in the early stages of ontogeny, the segmentation, etc., and the relation of such variations to variations in the mature animal.

Very little could be done towards an understanding of meteorology by isolated observations of atmospheric phenomena, yet on just this sort of observation many of our ideas of the methods of evolution are based. In a few cases large series of individuals have been examined, which had been collected at different times and at different places, but so far we know little or nothing of the limits of variation of any vertebrate within a limited territory, a single locality or anything of the annual variation. It is just this knowledge that we must have to test the current views of the methods of evolution.

At a recent meeting of the Board of Trustees of the Indiana University I was granted the use of the apparatus of the zoölogical laboratory for a summer station. The station will be a part of the Zoölogical Department of the University and will afford specialists in this department opportunities in field and survey work.

While no fixed courses will be offered, embryology and zoölogy will be taught, but only animals found native to the region will be utilized. An opportunity will be given to teachers and others over the State to study zoölogy in the field at a time when animal life is most abundant and the places of the interrelation of organisms apparent.

The Functions of the Spinal Cord from a Clinical Study. By Geo. A. Talbert.

In this day of great scientific research I know of no subject that presents such intense interest as some of the problems that confront the neurologist. This interest is not stimulated so much by the actual knowledge possessed as it is, perhaps, by the mist that envelops the subject. We might say that just enough is known to create enthusiasm for greater research.

The difficulties that observers have encountered are manifold, and for this very fact they have been led to be cautious many times in coming to a conclusion. The very methods that seem necessary to obtain the facts may defeat the end desired. The operator is never quite certain how near he has approached the normal condition. The artificial means that are often used must necessarily be rough imitations of the natural state. Let us take an illustration:

If the cerebral lobes of a frog are removed the animal seems to perform no movements except as a result of an external stimulus. The animal remains in a quiescent stage for hours and even days at a time. But if the proper stimulations are brought about the animal seems to possess the power of performing as complicated movements as a perfectly intact frog. There is a want of spontaneity. This would show that the seat of the will must be in the removed parts. If, however, the animal is kept alive for some time after the operation, we find that there are movements which point quite strongly to the guidance of an intelligent will. Some observers have found that if the frog is kept alive long enough it will catch flies and other food that comes in its way, and it is even known to bury itself in the earth at the approach of winter.

So from this we might have some doubt about our first conclusion. We probably would be led to think the shock that necessarily follows such an operation may to a certain extent give us abnormal phenomena, and really be a defeat of the normal condition. I have several times in my own observations looked upon the results with some apprehension. This furnishes us with an example of the many difficulties which are to be encountered in laboratory investigations. We

are presented with similar barriers when we try to draw conclusions from clinical cases. We are never quite certain of the mischief that may result from the di.-ease or injury.

Realizing fully some of the dangers that confront us, it will lead me to take a conservative position upon some of the points that I shall put forth in this paper.

I will now present some facts that I have been able to obtain from the study of a clinical case. I believe observation made in this way may in some respects be more valuable than experiments upon dumb animals in a laboratory, from the fact that we have an intelligent being to convey to us many valuable points, especially when it comes to the interpretation of sensations.

The following is a brief history of the case, as near as I have been able to ascertain:

In the summer of 1888 a man in Laporte County, Indiana, while trying to fix a binding pole on a load of hay, suddenly fell to the ground, striking with the greatest force upon what corresponds with the twelfth dorsal region. As a result the man was totally paralyzed below the point of injury both as to sensations and movement. He remained in this condition for ten months, when he was taken to Chicago and was operated upon by a distinguished surgeon. I have never been able to obtain the nature of the operation. At any rate the patient recovered to a certain extent. After this, however, there was no improvement up to the time the case came under my observation, which was four years after the accident and about three years after the operation.

The first time that I visited the patient I obtained all the data possible of the past history, and made quite a thorough examination to find the condition as it then existed. As a result I obtained the following facts:

There was total paralysis below the point of injury, except the inner side of both thighs as far down as the knees, and in the left limb down to the ankle; also, on a portion of the right side of the abdomen below the navel.

I did not see the patient again for about four weeks. In the meantime I consulted a physician, and we decided to try the effect of massage upon the paralyzed portions of the body. This treatment was kept up daily for about two weeks, when marked improvement was noted. The next time I investigated I found that the sensation of touch and temperature had been restored to the outside, as well as an increased amount on the inside of each limb. The sensations, however, were below the normal; as, for instance, the points of the dividers had to be placed from four to five inches apart in order to bring about a double sensation.

Power of movement was also partially restored, so that he was able to lift his limbs quite a distance from the bed; his toes, however, were still lax and possessed no sensation nor power of movement. Although the application of massage was continued for several weeks, the improvement seemed to be most marked during the first two weeks.

Let us now turn to the problem, and, if possible, ascertain its solution. I am, however, forced to confess that the more I look into the case the more complicated it appears.

In the first place it is very generally believed by physiologists that there are quite definite paths for the transmission of sensory and motory impressions in the cord. I do not intend to discuss here the disputed question of the position of these tracts, but it is sufficient to say that we are confident in this case that there were some obstructions at first in the cord, so that impulses could not pass from the brain to the limbs and *vice versa*.

It would seem at first sight that either this obstruction was removed, perhaps by the regeneration of the nerve tissue, or that the impressions had been educated into new paths.

The laboratory has given us quite undisputed evidence to show that abnormal paths are sometimes brought into use. For instance hemisection in the thoracic region of the right side of the cord of a dog will cause paralysis of the right limb. But, however, after the effect of the shock is passed, recovery is soon noted. Likewise hemisection a little higher on the left side of the cord brings about similar phenomena for the left limb. Again, if the experiment is tried still higher on the right side the story is again repeated. This compels us to believe that impulses would have to take a zigzag path. While this may be true of the dog we must not be too hasty in concluding that the impressions can take new paths in the human cord. It is a universal law that the higher we ascend the animal scale the greater is the precision of these paths, and injury to the most definite ones is more apt to have a permanent effect.

As to formation of nerve tissue we know it is more likely to take place in the lower than in the higher vertebrates. And if there was degeneration resulting from an injury then there might be grave apprehensions in regard to regeneration in so high a form as a human being, while it might be true in some of the lower forms.

The suggestions given above hardly make it clear. We are still left in doubt as to the virtue of the application of friction. It makes it more complicated when we think of the length of time that the man was paralyzed and how sudden was the recovery after the application of the remedy. It certainly would lead

one to think that the recovery would have been more complete if the case had been treated soon after the accident.

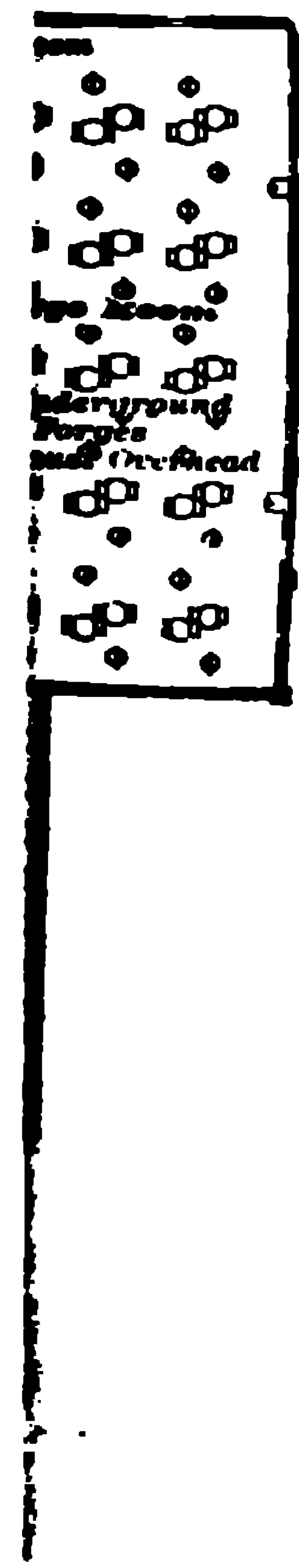
There is another way of looking at the problem, and perhaps it comes nearer if not quite to the solution. We said in the above that there was at first some obstruction, whatever that may have been, at the point of the injury in the cord, and as a result it caused the muscles below the point of injury to degenerate from disuse. The obstruction in the cord perhaps after awhile was removed, and it may have been at the time of the operation by the surgeon.

Let us now look to the laboratory and see if we can find evidence to aid us in solving the problem. It is a well known fact that there are nerve fibers that have a controlling effect on the calibre of blood vessels, or to state it more exactly, they hold the unstriped muscles in a certain state of contraction. It is known to physiologists as tone. This may be demonstrated by cutting the branches of the sympathetic system that supply the blood vessels of the ear of a rabbit. As a result the ear becomes flushed with blood, showing that the tone of the vessels is lost. It makes it more certain if the end of the severed nerve that supplies the ear is stimulated artificially, when it once more returns to the normal. If the stimulant be strong enough, it will so contract the coats of the vessel that the ear will appear pale. When we turn to the skeletal muscles, it does not appear quite so clear that they are influenced by the tonic effect of nerves. The observations of different investigators are at variance on this point. I believe that the preponderance of evidence goes to show that there is a tonic effect, or at least nerves which control the nutritive functions, or have what is known to physiologists as a trophic action. Taking, for instance, the severance of the sciatic nerve of an animal, and we will find that the muscles become flabby and that they do not possess the resistance that is noticed when the nerve is intact.

Time will not permit me to go into the argument showing that trophic centers exist in the cord. But assuming that these centers do exist, let us see how they carry out their work. In the first place, reasoning from the analogies of the action of the heart and other centers, we might with some reason suppose that the trophic centers, by virtue of their own metabolism, send out *de novo* efferent impressions to the muscles, thus having a nutritive effect. If we carry the analogy farther, we will have as good a reason for assuming that there are afferent impressions that pass to these centers and, as it were, modify the efferent impressions. There is experimental evidence to show that this is true. For instance, if the posterior root of a nerve is severed, while the anterior root is intact, it results in a loss of tone to certain muscles.

Let us turn back to our clinical case. We have tried to show that as a result of the injury there was a loss of tone, and we shall now try to show that it

one to think that the recovery would have been more complete if the case had been treated [illegible]



Let us turn back to our clinical case. We have tried to show that as a result of the injury there was a loss of tone, and, we shall now try to show that its return to the muscles was due to the remedy that was applied.

It does not seem improbable that the application of massage caused the afferent impressions which acted upon the trophic centers of the cord; and this in turn sent out efferent impressions to the tc ·eless muscles, and by that means they were restored to a condition so that they were able to respond to certain motory impulses.

Such an investigation of necessity has its limitations. The most essential facts needed will, of course, be in the dark as long as the patient is alive. An examination of the cord, in order to obtain the extent of the lesions, would make it more clear. Even had we the opportunity of examining sections of the injured portions, there might still be some doubt as to the revealing of all the facts in the case. We do not know to what extent the injured parts affect those which are apparently healthy.

Although the citation of this interesting case may not settle definitely the great problem whether there is skeletal tone, it will at least shed some light on the subject.

Does High Tension of Electric Current Destroy Life? By J. L. Campbell.

The Purdue Engineering Laboratory Since the Restoration. By Wm. F. M. Goss.

A little less than a year ago, Purdue University lost by fire, the larger part of its mechanical laboratory. The building was a fine one, only just completed, and was occupied by the Departments of Mechanical Engineering, Civil Engineering and Practical Mechanics; it had more than an acre of floor area, and was filled with an expensive equipment. The disaster was a trying one. Not only was the property loss apparently irrecoverable, but fear was felt that the uncertainty and delay in restoration would result in a loss of the prestige so honorably won by the University and a diversion of its student constituency in other directions. In this emergency the wisdom and courage of President Smart were quick to assert themselves. In a few weeks after the fire new machinery was running

in temporary quarters and the permanent building was in progress of construction. No work prescribed in the catalogue has been omitted from the course of any student.

The accompanying plan shows the laboratory as it now stands restored. The portion which was burned included the forge room, machine room and engineering laboratory; also, a three-story front containing offices, recitation rooms and drawing rooms. The outline of the old building has been preserved in the new, but the construction of the front has not yet been undertaken. All laboratory rooms have been entirely finished and equipped. A room has been added for experimental work with natural gas, and the locomotive testing plant has been provided for in a separate building. Not only has the capacity of the structure been increased, but the equipment also in every department has been improved. Time will not permit an enumeration, but the floor plan shows the location of apparatus now in place and in daily use.

It will be seen that while other lines of work have not been neglected, the equipment of the engineering laboratory is especially complete for work in steam engineering. The several engines shown are mounted as separate plants. This arrangement avoids any chance of interference among different groups of students who may be working with different engines at the same time. The Buckeye, Straight Line and Baldwin engines occupy the floor space, which before the fire was taken by the plant now in the annex. The Baldwin consists of a pair of 9½ and 16x18 Vouclain Locomotive Engines fitted up for the purpose of experiment. These engines are supplied with steam from the laboratory boilers and are run under the load of a friction brake.

The locomotive testing plant in the annex laboratory has been much improved. The plant shows Purdue's locomotive, Schenectady, in place, but the arrangement of the plant is such that any locomotive may be received and tested.

The engineering laboratory contains thirty-six steam cylinders aggregating over 1,500 horse power.

METHOD OF DETERMINING SEWAGE POLLUTION OF RIVERS. BY CHAS. C. BROWN, C. E.

[ABSTRACT.]

In 1888 I began work for the State Board of Health of New York on the investigation of the purity of water supplies drawn from rivers, with a detailed inspection of the water-shed of the Croton River from which New York City derives its supply. This was almost entirely an inspection of the actual sources of pollution, though a study was made of the chemical side of the question. The

investigations were continued during the following five years on the Hudson and Mohawk rivers, and reports of the work are to be found in the annual reports of the New York State Board of Health since 1888. The inspection of sources of pollution showed what went into the rivers, but the chemical analyses failed to show with sufficient definiteness the effect of this pollution on the water. We then tried the method of determining the numbers of bacteria in the water, and while that was fairly satisfactory when the conditions were simple, we found it to be absolutely necessary that there be no disturbing conditions whatever, so that it was difficult in most cases to find a time when the method could be applied.

We are told by the bacteriologists that the bacteria which are objectionable in drinking water are the bacteria introduced by sewage. We therefore concluded that we should determine the proportion of such bacteria in the water. At this juncture Dr. Theobald Smith, of the Bureau of Animal Industry, Department of Agriculture, at Washington, suggested a method of making this determination, which he was developing, and we applied the method to our study of the rivers with results that are so far quite satisfactory.

The method rests upon the assumptions that *Bacillus coli communis* is a species which is very common in sewage, which does not proliferate under ordinary conditions of running water, and whose numbers may therefore be assumed to bear a fairly definite relation to the amount of sewage pollution. Numerous check observations uphold these assumptions.

The method of determining the numbers of "coli" in a given sample uses the fermentation tube, now frequently called the Smith tube in bacteriological laboratories, as the use of the tube in bacteriology has been developed by Dr. Smith.

The tube, as shown by the pictures, is a bent tube with one end closed and a bulb at the other. It is filled with a clear bouillon of beef with peptone, salt and 2 per cent. of glucose, properly neutralized, or made slightly alkaline. The tube and filling are sterilized by boiling on three successive days, the air driven off into the closed end of the tube, being decanted so as to leave the liquid in the tube sterile, and that in the closed end of the tube without oxygen. The liquid in the bulb is now inoculated with bacteria and the tube placed in an incubator kept at 98° F. for 36 to 48 hours. Classifying the bacteria likely to be found in water as motile and non-motile, and as aerobic and facultative anaerobic, it is readily seen that non-motile and aerobic germs will develop in the bulb only, and will leave the liquid in the tube clear. Motile bacteria that can develop without oxygen will reach the tube and change the character of the liquid. The temperature of 98° at which the tube is kept will prevent the development of nearly all the common water bacteria. Certain bacteria produce gas from media containing

glucose in varying amounts, the composition of this gas varying from 0% CO_2 to 100% CO_2.

Bacillus coli communis and two others, much less common but also sewage bacteria, produce 0.4 to 0.7 of a tube full of gas, of which 0.5 to 0.7 is CO_2. All others observed produce amounts of gas and of CO_2, readily distinguishable from those, and are, therefore, easily dropped from consideration.

The process in examining a sample of water is to prepare a sufficient number of tubes of sterile bouillon, and an incubator. The sample of water is distributed among the tubes, an equal amount in each, the amount varying according to the impurity of the water. With a pure water 1 c.c. may be used. With sewage $\frac{1}{100}$ c.c. may be found to be too much. The tubes are placed in the incubator and left at the constant temperature of 98° for thirty-six hours or a little more. They are then taken out and the proportion of gas in each tube is determined. Those promising to contain *Bacillus coli communis* or its companions are treated with an alkali to absorb the CO_2, and the propor ion of CO_2 is thus determined. From the two determinations the number of *Bacillus coli communis* in the sample is derived, and thence the number in a c.c If much more than half the tubes inoculated from a sample contain "coli" the amount of water used in a tube has been too large to produce a result which will compare closely with other determinations. Likewise, if the sample has been diluted with sterilized water before inoculating the tubes, too small a number of tubes with *coli* shows too great dilution to produce results that will check up with others from the same sample.

Many results have been obtained by this method in the last three or four years which seem to give closer determinations of the amount of sewage pollution than any method heretofore used. The method has not yet had wide enough application to demonstrate its value under various conditions, but we feel certain that it has great value in the examination of streams used or proposed as sources of water supply for cities.

I have not time in the limits of this paper to give the results, and give the methods only, as perhaps the more suitable for the purposes of this association at this time.

PSYCHOLOGICAL LABORATORY OF INDIANA UNIVERSITY. BY W. L. BRYAN.

INTERESTING DEPOSIT OF ALUMINA OXYHYDRATE. BY GEO. W. BENTON.

[ABSTRACT.]

1. Report of trip to Southwest Missouri, March, 1894.
2. Alumina found in pool of spring water.
3. The springs brought in the deposit.
4. A careful survey of the region proved that the deposit is forming, and is not stored up in quantity.
5. The source a pure aluminum silicate which abounds in quantity in that region.
6. Some possible uses of the deposit and the silicate.
7. Theory of the decomposition.

OBSERVATIONS ON THE GLACIAL DRIFT OF JASPER COUNTY, BY A. H. PURDUE.

The writer begs to state that his experience in glacial geology, the time spent in field work on the material herein presented and the territory explored are all limited; and that he does not claim for the paper any more than its title indicates, viz.: observations on the glacial drift of the locality named. It is proper to state further that these observations have been confined mainly to that part of the county lying south of the Iroquois River.

Jasper County is situated in the northwestern part of the State, with Porter County intervening between it and Lake Michigan, and is separated from the State of Illinois by Newton County. It is, therefore, in one of the most active fields of all the glacial epochs. Mr. Collett claims (Twelfth An. Report Geol. and Nat. Hist. of Ind., page 66,) that glacial erosion has removed from fifty to two hundred feet of rock from the entire surface of the county. This great erosion, and subsequent glacial action, has left it practically level, and with poor drainage, so that numerous peat marshes abound in all parts of the county, varying in size from a half acre and less to several thousand acres. Notably among the larger ones are "Gifford Marsh," a swamp of 12,000 or 15,000 acres, lying twelve miles northeast of Rensselaer, and the "Blue Sea," a similar marsh, lying in the southeastern part of the county. Only the former of these has been visited by the writer. It is an old glacial lake filled up with peat and muck, varying in depth from three to fifteen feet, the monotony of which is broken by numerous accumulations of sand, which in form imitate drumlins.

Many wells have been drilled in all parts of the county, but no compilation of the data furnished by them has been made, so that nothing is known of the subglacial topography. It might be stated, however, that the drift varies in depth

from a few feet, as at Rensselaer, to two hundred feet. The latter extreme depth has been found nowhere, so far as I have learned, except on the moraine which extends in a northeasterly direction across the county, passing one and a half miles north of Rensselaer.

This moraine is possibly the most marked topographic feature of the county. In width it will average probably a mile, and in height it varies from twenty to eighty feet. It is said by Mr. Leverett, of the U. S. Geological Survey, to extend northeastward into Pulaski County and southwestward through Newton County into Illinois, and is thought by him to possibly be interlobate between the Saginaw-Erie lobe from the northeast and the Lake Michigan lobe from the north.

One of the first things to attract attention in the study of this locality is the great number of sandy ridges everywhere prevailing. With reference to direction it appears that there are two classes of these. One class extends almost parallel with the above mentioned moraine. I have observed them in Pulaski and Jasper counties, northwest of Monon, and in passing over the Monon Railway from two miles northwest of Rensselaer to Parr. The other class, which I have observed only south of the moraine, have an average course of about S. 30° E., and consequently run in a direction almost at right angles to it. It is the latter class to which we wish to invite attention.

These ridges are of two types, each frequently passing into the other. For convenience we will speak of them as the symmetrical and the unsymmetrical.

The most common form is the symmetrical. These are low, broad, symmetrical ridges. They vary in width from forty yards to an eighth of a mile. Though frequently running into each other they are in the main parallel, and often are crowded so close together as to give the surface a billowy appearance. The troughs between them always contain rich, black soil, formed from the decay of peaty matter, and indicating former shallow lakes. An excellent view of this type is presented along the "Line Road" from Rensselaer to Remington for a distance of five miles south of the former place. The view along this road shows them to run east and west, but a short distance to the east they swing to the south and southeast. All the ridges of this class are composed largely of sand, though they contain enough vegetable mould to prevent shifting by winds, and permit of an excellent yield to the farmer. I have never noticed any gravel in them except north of the Iroquois, in the vicinity of the large moraine. Bowlders are sometimes seen along and near their bases, but seldom on the swell of the ridge, except also in the vicinity of the large moraine.

The unsymmetrical type differs from the symmetrical in size and shape, in being composed more largely of sand, and in not being so numerous. They are

much larger than the symmetrical, varying in height from five to twenty-five feet above the general level. The average is probably about ten feet. The south and west slopes are gradual and more or less broken, while the north and east slopes are steep and even. Horizontally these slopes are very sinuous, resembling the banks of winding streams; but the fact that at their bases, often stretching to the north and east for a mile or more, are extremely level expanses frequently covered with peat, forcing upon even the unobserving the recognition of old lake beds, dispels the idea of their being such. At the same time the winding course of the ridges prohibits the idea of their having been thrown up by wave action from the lakes. In many places these ridges are too sandy to be cultivated with profit, in others the soil is good, and at a few points, to be mentioned later, gravel has been found. They are frequently cut through by what apparently were escapes for the water confined by them. In these cuts, which usually reach to or near the base of the ridge, bowlders can pretty confidently be searched for. Bowlders are also occasionally found along their bases.

Only in the gravel pits above referred to has the writer seen any indication of stratification. Two of these pits are situated a mile and a quarter west of Rensselaer, near the Iroquois River. There are three others a mile and a half south of Rensselaer. Places in these show attempts at sorting by rapid and changeable currents, but the greater part of the material is unsorted, and it would seem that their deposition was effected almost wholly by direct glacial action.

Let it be repeated that the two types often grade into each other. A ridge that in places presents the most rugged aspect of the unsymmetrical, may, in the course of a mile, grade into the most feeble of the symmetrical type; and at a point about three miles north of Remington an unsymmetrical ridge grades into a low, flat ridge covered with numerous bowlders, and evidently a moraine.

Of course, the thing of interest in connection with these ridges is the question of their origin. It has been claimed (Twelfth An. Rep. Geol and Nat. Hist. of Ind., page 66) that they are dunes formed along the northeast and east shores of former lakes, and were produced by southwesterly winds. While the examination of numerous cuts has not disclosed the least sign of lamination by either wind or water, there seems to be no doubt that the unsymmetrical ridges are due very largely to æolian action; but it does not seem that the low, flat, symmetrical ridges, so frequently connected, or passing into each other and forming the rims of ponds could have been produced in this way. The fact that the two types grade into each other indicates a common origin at least of their basal portions. Also the fact that bowlders are more numerous along and near the bases of these ridges, especially the symmetrical type, than elsewhere, together with the fact that

bowlders are liable to be found in the cuts through the large ridges is considered significant. It would also seem that the parallelism and continuity of the ridges of both types are greater than could be expected of deposits determined alone by wind. In the gravel pits south of Rensselaer there is nothing to indicate that the adjoining portions of the ridges were formed in a manner different from those portions where gravel is found.

The above facts suggest the possibility of the symmetrical ridges having been formed directly by glacial action as the glacier receded to the northeast; and in some cases they have served as lodgment tracts for the accumulation of wind-blown sand, in that way largely determining the course and extent of the unsymmetrical or dune type. But more field work is necessary before considering this beyond a hypothesis.

There are at least two bowlder belts in the county, but because of limited time I have not been able to follow them out. One of these is north of Remington and the other is east and southeast of Rensselaer. The latter I have traced from the junction of the Iroquois and Pinkamink rivers southeastward for a distance of three miles. It will probably be found to extend southeastward and eastward into White County, forming the southern border of the old lake through the bed of which the Monon Railroad passes, from Lee to Pleasant Ridge. The careful location of these bowlder belts will probably throw light on the glacial phenomena of the locality.

CONCERNING A BURIAL MOUND RECENTLY OPENED IN RANDOLPH COUNTY. By JOSEPH MOORE.

Southern Randolph and the adjacent portion of Wayne, is in the main a level tract, the land during ordinary seasons being rather wet.

Besides a number of well-defined made mounds in the neighborhood of Lynn Station on the G. R. & I. R. R. there are frequent examples of natural mounds. These are usually much larger than the artificial mounds. They may be compared to drift islands surrounded by flat areas of dark colored soil. Some of these mounds of modified drift have been utilized by ancient peoples as burial grounds. The one of which I speak is a fraction over a mile west of Lynn Station. It is about 150 yards in circumference and 18 to 20 feet high, and is so symmetrical as to have the appearance of a made mound; but in a wide cutting made through it by the gravel haulers the structure clearly shows an aqueous deposit from top to

bottom. In this mound the workmen say they have opened "more than a hundred graves." They "counted till they reached seventy." Quite a number of the skulls were sufficiently preserved to bear handling, even after being for a short time exposed to the air. Some of them on being treated with a solution of glue have rather a fresh, recent look. Very many of the bones were broken to crumbs by visitors in sport. Some of the skeletons were in a sitting posture with the chin crowded upon the knees.

The depth of the graves was from a yard or less to twelve feet and more. The skeletons were of both sexes and various ages, some quite young. It was alleged that a horse's bones were found, but I was unable to find the least scrap. They also tell of a dog's skull with the teeth all perfect. This is possibly so, but it would seem more likely that it was the head of a wolf, which is quite similar. Quite a number of implements were found, some of which are here on the table. One skeleton was found with a large dart in each hand.

They assert that a scapula was found pierced by a flint dart and that the dart was lodged in said bone, but that the bone immediately crumbled from about it. There were beads of bone, shell and copper—but few of the latter—also copper rings, tube pipes and various other things, the uses of which are not very well known.

You will see in the skulls presented for your examination that there is quite a diversity. Two of them are of the brachycephalic or short-head type, one barely so, the other extremely so. The one has the lateral diameter in the proportion to the fore and aft, as 86 to 100, the other of 92 to 100. The others are all orthocephalic, though one of them approaches to the long-head type.

You will note, not only the extent to which the teeth are worn, but also the peculiar manner of the wearing. It will also be seen that decayed teeth, caries of the bone and also signs of gum-boils and abcesses are not confined entirely to civilized races.

The upper wisdom teeth in one of the skulls show, each, examples of enamel tubercles on the fangs, a rather rare phenomenon, as I understand.

You will note also in one of them an extraordinary double suture at upper border of occiput.

A question of interest: Did such diverse skulls belong to the same tribe, or did different tribes at different times bury in the same grounds?

REVERSAL OF A CURRENT IN THE TOEPLER-HOLZ ELECTRICAL MACHINE. By J. L. CAMPBELL.

A Florida Shell Mound. By U. F. Glick.

These old shell mounds are quite numerous on the Atlantic coast of Florida, and are located principally on both shores of the salt water lagoons, the greater number being found on the western or mainland shores and near the water.

The mound in question is on the western shore of the Halifax lagoon, and within the town limits of Daytona, Valusia County, Florida. It is an enormous "kitchen midden" or back door refuse heap, covering at least an acre of surface ten feet thick, and containing something like four hundred thousand cubic feet of shells, bones and pottery. We had a good opportunity of studying the mound, measuring sections, etc., as it was being hauled away to construct streets and roads. More than half this enormous pile of rubbish has been removed in the past two years, opening up the mound in its various features to the curious student and archæologist.

The contents of the heap are arranged in layers or strata of shell and soil, the layers varying in thickness in different sections (as per chart), the rule being a layer of shells from two to three feet in thickness, and resting on this from eight to ten inches of soil. There are two or more such formations of decomposed shell soil found between the bottom and top, the first being from three to four feet above the general level, which is from three to four feet above low tide in the lagoon near by. Above this soil strata is another of shell two feet thick, followed by another of soil, several feet more of shell reaching to the top. The surface of the mound has quite recently been covered with a heavy growth of forest trees, such as live oak, water oak and wild orange, some of these several hundred years old. A portion of the mound is enclosed, and forms part of the grounds of a Daytona resident. These grounds are rich in tropical and semi-tropical plants and trees, the aloe, banana and tropical pawpaw growing luxuriantly with the fig, oleander and orange. Shells, bones and pottery form the principal part of the contents of the mound, about 95 pt. shell, 5 pt. bone, pottery, roots, etc. The orange and live oak roots find their way through the ten feet of shell and soil into the moist earth beneath, making all imaginable crooks and angles on their way down.

The oyster is the shell found in greatest abundance. The small salt-water clam, conch, quahaug clam and sea-snail follow in the order named. When the water is not too fresh, the oyster is found in the Halifax lagoon. The other shells belong to the ocean. The inflow of fresh water often destroys the oyster. Evidence of this is seen in the mound by a layer of oyster shells being covered by one of the small clams from the ocean beach. The rough (Fulgar Canaliculatas) and smooth (Pyrulus Canaliculatas) conches are distributed throughout the heap. The larger

of these are often broken into, to more easily obtain the animal, the large sea-snail being treated in the same manner. The question may be asked as to how the thick, heavy walled shells were broken, as no stone implements were found. By examination of the rough exterior of the conch (Fulgar canaliculatas), in it may be found an excellent implement for the purpose. Bones and pottery are also found throughout the mass. The bones are chiefly those of animals taken in the chase, deer, bear, lynx, alligator, dog and fish, of the latter only the vertebræ remains. The greater portion of these bones crumble to pieces on exposure to the air. The pottery is almost entirely fragmentary, no whole vessels being found to my knowledge, however, the restorations which have been made from large fragments would indicate vessels of ten to twelve gallons capacity. The pottery of the lower layers is rude and rough, and without any ornamentation whatever, while that taken from the upper strata is better made and with some efforts at ornamentation.

The size of these aboriginal cooking vessels would seem to prove that the living shell was heated or boiled to more easily obtain the animal. Shells of the quahaug clam (Venus mercinaria), abundant in the refuse heap, are now rare on the adjacent coast. Attempts have been made to determine the age of these ancient heaps of rubbish, but such determination in the light of present data, may be quite conjectural. However, from the evidence it is obvious that they are not recent, but must run far back into the dim ages of the past. It is hoped that further investigation may throw more light upon the manners, customs, habits and history of the people through whose instrumentality these immense accumulations were formed.

A Note on Rock Flexure. By E. M. Kindle.

The phenomenon of rock flexure is familiar enough, as it occurs in anticlines and synclines in many regions. These natural bendings of rocky strata, however, afford no data for determining the actual values of the factors producing them, the pressure and the time during which it has acted. The time factor required to produce bending without fracture in a solid stone is so large as to have prevented any except accidental experiments in this direction.

Such an experiment I discovered two or three years ago in progress in a country cemetery one-half mile south of the village of Nineveh, Ind. Over one of the graves there has been placed a horizontal marble slab, which was formerly supported by a brick wall eight or ten inches high surrounding the grave. At the time of my first visit this wall had crumbled down along the greater portion of each side of the slab, leaving it supported mainly by the portions which still

remained intact at the ends of the slab. The long continued support of the slab at the extremities alone had caused it to sag to such an extent as to be quite noticeable even to the casual observer.

Recently I revisited the place to determine exactly the amount of flexure which the slab had undergone. I found it had been broken into five or six pieces by vandals. On one of the pieces, which had formed a portion of one side of the slab near the middle, I measured carefully the amount of flexure. This piece measured two feet eight and one-half inches along the original edge of the slab. The flexure along this direction was one-tenth of an inch. The dimensions of the original slab were: Length, six feet one inch; breadth, two feet; and thickness, one and four-fifths inches. The measurement of the fragment will not permit of an exact estimate of the amount of flexure in the original slab, but would seem to indicate a flexure of not less than a quarter of an inch, and possibly more. The slab bears the name of Sarah Mullikin, and gives the year 1847 as the date of her death. I ascertained that the stone had been put in position shortly after this date. The flexure could not have begun, however, until the decay of the middle portion of the supporting wall had made considerable progress. This we may presume to have been not less than ten years after its construction. If we suppose the gradual bending to have been in progress since 1858, about ten years after the stone was put in position, then we have a flexure of about one-fourth of an inch in a slab one and four-fifths inches thick, produced by the stress of the stone's own weight, acting through a period of thirty-seven years.

THE ALTERNATE-CURRENT TRANSFORMER WITH CONDENSER IN ONE OR BOTH CIRCUITS. BY THOMAS GRAY.

ELASTIC FATIGUE OF WIRES. BY C. LEO MEES.

A WARPED SURFACE OF UNIVERSAL ELLIPTIC ECCENTRICITY. BY C. A. WALDO.

ACCURATE MEASUREMENTS OF SURFACE TENSION. BY A. L. FOLEY.

EFFECT OF THE GASEOUS MEDIUM ON THE ELECTROCHEMICAL EQUIVALENT OF METALS. BY C. LEO MEES.

Some New Laboratory Appliances in Chemistry. By H. A. Huston.

[Abstract.]

A machine for use in making solutions of difficulty soluble substances at various temperatures was described. Also a new form of stirring machine for use in precipitating ammonium, magnesium phosphate and similar work.

Cuts are necessary for a full understanding of the paper.

Volumetric Determination of Phosphorus in Steel. By W. A. Noyes and J. S. Royse.

The Action of Ammonia Upon Dextrose. By W. E. Stone.

[Abstract.]

Dextrose is commonly regarded as belonging to the class of chemical compounds known as *aldehydes*. Several of the characteristic reactions of this class of compounds are, however, not given by dextrose or have not been heretofore observed. Chief among these are the reaction with a decolorized fuchsin solution and the formation of ammonia compounds.

This paper describes the preparation and properties of a crystallenic compound of dextrose with ammonia which seems to belong to the class of aldehyde-ammonia derivatives. Its importance lies in the contribution of this new proof of the aldehyde character of this typical sugar and that without much doubt a whole series of such derivatives can be prepared from the other so-called glucose sugars.

Action of Zinc Ethyl on Ferric Chloride and Ferric Bromide. By H. H. Ballard.

The Sugar of the Century Plant. By W. E. Stone and D. Lotz.

[Abstract.]

The "maguey" plant or *Agave Americana* furnishes the materials for many important industries in Mexico. Its juices obtained at the flowering period contain about 15 per cent. of a fermentable sugar. By their alcoholic fermentation are produced several beverages of more or less intoxicating nature. The fibre of the leaves is utilized in many ways and the juices of the plant when treated with ash lye make a kind of soap.

The paper deals more especially with the character of the sugar present which has already been described by two Mexican chemists as a distinct and new kind of sugar. The results given in this paper go to show that this sugar is not different in any way from that of the cane or the beet-root or the maple. That it is a definite chemical compound known as sucrose and that without much doubt the announcement of the Mexicans of the discovery of a new sugar was based upon erroneous observations.

Camphoric Acid. By W. A. Noyes.

Action of Potassium Sulfhydrate Upon Certain Aromatic Chlorides. By Walter Jones and F. C. Scheuch.

A New Phosphate. By H. A. Huston.

Dip of the Keokuk Rocks at Bloomington, Indiana. By E. M. Kindle.

In the course of some stratigraphical studies in Monroe County it became desirable to ascertain, as accurately as possible, the dip of the Keokuk strata. As is generally the case with Indiana rocks the Keokuk strata are not sufficiently inclined to admit of the use of the clinometer in determining their dip. It was therefore necessary to determine the relative elevations of two points lying in the direction of dip in some stratum, and separated by a known distance. It is essential in this method of estimating dip that a stratum or horizon be selected which can be positively identified at different points.

The contact of the Keokuk with the Knobstone is readily recognized wherever it outcrops in Monroe County, both by the striking paleontological and lithological differences between the two groups. The Keokuk is everywhere at the contact with the Knobstone an impure fossiliferous limestone, while the Knobstone is a massive sandstone entirely without fossils. I therefore selected the contact of the Keokuk with the Knobstone as the most convenient stratum, from which to determine its dip. The ravines north of Bloomington afford numerous exposures of the contact. Two points for the comparison of elevations were selected, one a mile and a half north of Bloomington on the North Pike, the other in a ravine nearly due east of the first. A surveyor's transit was used to

determine the difference in level between the two points. For assistance in this work I am indebted to Mr. C. E. Siebenthal and Mr. George Champ. The distance between the two points was estimated by stadia measurement. A reduction of the data obtained showed the points to be 1½ miles apart, and the dip of strata between them to be at the rate of 63.6 feet to the mile. This result was so much larger than was anticipated that the ground was gone over a second time by Mr. Champ and myself. The second survey, with a "Y" level, confirmed the correctness of the first, thus showing the Keokuk strata to have a dip west of nearly 64 feet to the mile in the neighborhood of Bloomington.

Wave Marks on Cincinnati Limestone. By. W. P. Shannon.

In the southwest part of Franklin County, three miles west of Oldenberg, in the bed of Salt Creek, are good examples of wave marks on Cincinnati limestones. These wave marks are nothing new. They have been referred to by different students of the Cincinnati strata, and are characteristic, since they occur at all horizons of the Cincinnati rocks. This does not signify that every stratum or layer is so marked, but that such marks are rarely found in other than the Cincinnati limestones. Another stratigraphic character of the Cincinnati rocks is the alternation of strata of limestone and shale. The strata are thin, each one being usually made of a single layer or ledge.

Within a distance of one-quarter mile up and down the bed of the creek, four wave-marked strata are exposed, and according to the law of the Cincinnati formation, each one is overlaid by a stratum of shale. Of these four wave-marked strata the three uppermost are consecutive, not consecutive strata, but consecutive limestone strata.

In no two strata are the wave marks in the same direction or of the same size. All four of these strata are fine grained, compact limestone, showing that they were made of calcareous sand or mud. A description of two of these wave-marked strata will be sufficient, the two which have the greatest exposure. One forms an uninterrupted floor to the stream for a distance of 100 feet; the width of this floor is 25 feet. The wave marks are transverse to the course of the stream, and if we stand at the lower end of this area and look up stream it is hard to keep from thinking that we are looking at real undulations in water. It requires a conscious effort to keep from identifying the effect with the cause. If we measure these waves, they are about two feet from crest to crest, with a vertical distance of about three inches from crest to hollow. Besides wave marks this ledge shows mud

cracks, which have checkered the surface into roughly hexagonal areas. The existence of mud cracks in limestone is a valuable note. In the American Geologist, Vol. IV., No. 6, is an engraving of a slab of Cincinnati limestone, showing mud cracks. The specimen was found by Prof. C. W. Hargitt near Moore's Hill, and is now in the Moore's Hill College. The association of mud cracks and wave marks in the same ledge is, no doubt, a valuable note in working out the conditions which gave rise to alternating sediments of limestone and shale. The wave marks are evidence that the sea was so shallow that slight undulations touched bottom. The mud cracks are evidence of some form of land, a low tide island, at least. The two together seem to show a marked shallowing of the sea during the history of one limestone stratum, or a transition from lime-depositing to shale-depositing conditions.

The other wave-marked stratum to be described presents a surface of exposure about 100 feet by 50 feet. The waves are about three feet from crest to crest, and the hollows are about three inches deep. These wave marks differ from those of the other three strata in that they are curved like rainbows. These curved waves are evidence that the undulations of water that caused them were modified by neighboring shoals or land, the results of a shallowing sea.

In this paper I have given only certain facts of structure and have assigned what I believe to be the immediate causes of these structures. The great problem of the Cincinnati formation is the invariable alternation of limestone and shale strata. The structure noted may be helpful in working out this problem.

STRUCTURAL GEOLOGIC WORK OF J. H. MEANS IN ARKANSAS. BY J. C. BRANNER.

CORRELATION OF SILURIAN SECTIONS IN EASTERN INDIANA. BY V. F. MARSTERS AND E. M. KINDLE.

SOME NEW INDIANA FOSSILS. BY C. E. NEWLIN.

EXTINCT FAUNA OF LAKE COUNTY. BY T. H. BALL.

The object of this paper is to present, so far as is known, some account of animals, supposed to be native, that no longer are found in the county of Lake.

1. I may as well name first one that has surely been extinct quite a number of years, the mastodon, remains of which were found near an old beaver dam

about three miles west of the present town of Crown Point. The portions found were the teeth, weighing some four pounds each. I am sorry not to have in my possession any of its bones, but the remains of a huge quadruped were found there without a doubt.

2. I name next the beaver, *Castor fiber* or *americanus*; remains of the works of these busy toilers having been found in different parts of the county, and some rodent bones, supposed to be of beaver, were exhumed at the head of Cedar Lake, along with human remains, October 1, 1880, the human skeletons having been there more than two hundred years. No living beaver have been seen in the county for more than sixty years, the settlement of the county bearing date of 1834.

3. There is some evidence found in the records of the early French explorers that the buffalo or American bison roamed over the prairies and marshes of northwestern Indiana two hundred years ago, but that animal, in the region named, has certainly been extinct beyond the reach of the knowledge and memory of two generations of hunters and trappers.

4. Some individuals of the black bear species, *Ursus americanus*, were found in the county some sixty years ago by the very earliest settlers. One was shot by Solon Robinson where is now the town of Crown Point. The few seen were probably stragglers, their proper domain just touching the broad prairie region beginning in the northwestern corner of the State.

5. Elk horns have been found at Cedar Lake and in the West Creek marsh, one of which is now in my possession, showing that once, perhaps a hundred years ago, this stately animal fed beside these waters.

6. The earlier inhabitants of the county found a few wild cats, probably *Felis catus*, one of which species was killed at the head of Cedar Lake, in an alder thicket or swamp, early in 1838. A large and formidable looking animal he seemed to me to be, as, with the eyes of a young hunter boy eleven years of age, I looked upon him. For years that thicket, which was on my father's land, was known as Wild Cat Swamp. These cats may be called extinct since 1840. Individuals also of the lynx species or variety, *Lynx rufus*, it is claimed, were seen and heard in early times, fifty years ago. I myself saw in the night, going down from a tree to which we had chased it, an animal that, judging from its movements, might have been a lynx, but none were then killed. Miss Belle Dinwiddie, of Plum Grove, is authority, and competent authority, for the statement that an animal of the cat kind and called a lynx was killed near her home a few years ago. It is probable that only one species of *Felis* was native.

7. The common American deer, *Cariacus virginianus*, was once very abundant in the county. The following is one of Lake's historic records: "When putting on the roof of the Rockwell house in Crown Point, V. Holton and others saw, coming out from Brown's Point and passing out across the prairie to School Grove, a drove of deer, one bounding after the other, according to their best count in number one hundred and eleven."

I never myself saw so many at one time, but I have ridden in among them by night and have seen them by day in numbers sufficient to delight the eyes of a hunter or of a naturalist. But not one can now be found on these five hundred miles of area. Several years ago there was a cold, hard winter. The snow was quite deep, and on the snow came what is called a crust. On the top of the crust the dogs, the boys and the men pursued the almost helpless deer and slaughtered them without mercy. Few survived, and now, as I have said, of these beautiful animals and of the spotted fawn that could be seen in the spring time, in all the island groves and wild pastures there is left not one.

8. The habitat of the timber wolf, *Canis lupus*, extended into the south-eastern part of Lake County, into what is called Eagle Creek Township. These have been considered as not actual denizens for fifty years, but a few individuals have made occasional visits, some in 1872, and three or four in 1893, one of which was killed by Mr. O. Dinwiddie, of Plum Grove.

9. The bald eagle, *Haliaetus leucocephalus*, once a native, for a nest of this grand bird, perhaps its last, was found in 1835 in the eastern part of the county, and gave name to a stream and the stream to a township, I name next, as now extinct. One fine specimen of this species that was shot on my father's place at Cedar Lake in 1857, measured from tip to tip of its outstretched wings seven and a half feet. It is possible that one may now and then fly for an hour over the southern shore of Lake Michigan, but they do not sit now, as in boyhood I used to see them, on the great oaks at Cedar Lake to watch the fish hawks; their native home is in the county of Lake no more.

10. I name, last, a reptile that the citizens of Lake may well hope has become extinct, although possibly some few yet linger amid the growing civilization, the ground rattle snake, perhaps *Crotalus horridus*, quite poisonous, and fifty years ago very abundant. I had a dog that disposed of other snakes, but when he found one of these he backed out and kept away. The last one that I saw was killed ome four years ago.

It is not always easy to trace a border line, and some other species I might call extinct of which a few individuals may still be found, but in addition to these ten species, some of which made not a little wild life, I will name as approaching

extinction the prairie wolf, *Canis latrans*, of which in boyhood I shot one and trapped one; the otter, the mink, and the raccoon; also the black squirrel, the pinnated grouse, the partridge and the quail. As a citizen of Lake County I may say, with most of them we dislike to part. We had them, some of them by the thousands, once, but now they are rapidly disappearing. Yet, notwithstanding our fourteen railroads, our thirty towns and villages, with their constant hum of business, and our thousands of farms, we still have of mammals, birds and reptiles, of both vertebrates and invertebrates, quite a rich fauna left for the study of childhood and youth, for the investigations of the naturalist; but very little now for the sportsman, the hunter, or the trapper, where, according to the estimate of E. W. Dinwiddie, "250,000" wild fowls have been shot in a single season, and some sixty thousand musk rats have been trapped in a single year; where a thousand ducks have been in one sportsman's house at one time; where the wild geese have been almost by the million, but where along our southern marsh they make their nests no more.

All these that I have named are becoming so rapidly extinct that they will soon no longer form a part of our fauna, and Lake County will lose its former renown as the sportsman's paradise.

THE SYNONYMY OF THE OHIO RIVER UNIONIDÆ. BY R. ELLSWORTH CALL.

[ABSTRACT.]

The Ohio River is the original source of most of the earlier described Unionidæ of North America. The French explorers collected these forms and sent them to Europe. Among naturalists there, who described these collections, was Lamarck, who thus becomes the original source of information. Later Say, Rafinesque, Conrad, Barnes and Lea severally studied the Unios collected in the Ohio and gave different names to the same forms. There has resulted a confusion of specific names that has greatly retarded a correct understanding of the shells of this river. This paper redescribes the shells of such species as are imperfectly known, gives the synonymy of the several forms, has complete bibliographic references to original publications and illustrations, and has full notes on the geographic distribution of the several forms throughout the drainage basin of the Ohio.

An attempt at a natural grouping has also been made. An early—the earliest described—form has been made the type of the several divisions which are to be taken, not as sub-generic divisions, but as arbitrary morphologic sections, each of which will include forms that are closely alike in essential details. Through this grouping the facts lead to a rather extensive synonymy.

THE STREPOMATIDÆ OF THE FALLS OF THE OHIO. BY R. ELLSWORTH CALL.

[ABSTRACT.]

This paper lists the various forms of the several genera which occur at this locality. Notes on habits and abundance, on synonymy and geographic distribution are included. The species found number only ten nominal ones, and of these several are synonyms. There are bibliographic references to original descriptions and to published figures.

The ten species found, are distributed unequally, among four genera.

The conditions at the falls of the Ohio are well suited to this form of molluscan life, and they may be summed up in terms of the rich development of the several species in the matter of number and perfection of form. The locality is one of optimum conditions for the development of strepomatid life.

THE SWAMPS OF FRANKLIN COUNTY. BY M. H. STOOPS.

To one entering Franklin County by rail, he gains the impression that he is far distant from a swamp. On either side of the White Water River are high hills, which overlook the river valley. At times the train seems to be rushing into one of the hills, when it suddenly glides around the side, leaving the traveler to gaze at the side of the hill, which rises abruptly to a hight of three hundred feet.

This river valley owes its origin to the glacial period. In this section of the State the drift extends south into Kentucky. It is doubtful whether the ice extended farther south than this point. The melting of the vast quantity of ice formed a mighty river that rushed to the south and cut out the White Water valley. The present White Water River was the main channel of the glacial river for southeastern Indiana. This river wore through the rocks to a depth of over five hundred feet. Although the present hills are only from three hundred to four hundred feet high. The valley has been filled with drift to the depth of about one hundred and fifty to one hundred and seventy-five feet at Brookville. On either side of the valley, after ascending the hills, the county is comparatively level in places, except close to the tributaries of the river. Some parts of the county are very level and can only be cultivated because of artificial drainage.

In the northeastern part of Franklin County was the swampy region. The early settlers in this county ignored that section, they settled the river valley and hills before any one had the courage to even try the highest portions of the swampy region at that time, what is now Bath Township, and the wealthiest township in

Franklin County was the home of the beaver, bullfrogs of immense size croaked through the early spring months with nothing to disturb their music except the quack of the wild duck and the squall of the goose. Bath Township is on the divide between the White Water and Miami river systems. Part of the land is drained by the Miami and part by the White Water river. The swamps were caused by large quantities of ice being left on the land to slowly melt, as it melted the water was carried off to the east, south and west, while a great part of their debris was left on the ground which partially buried the ice, this ice slowly melted and left large ponds of water all over the township.

As the soil carried down by the ice was an impervious clay, the water could not very easily escape except by evaporation, when the snows and rains of winter came they were again filled to overflowing.

They varied in size from a quarter of an acre to a hundred or more acres. As the settlers became more and more numerous they were pushed nearer and nearer the wet lands, as it was impossible to raise anything on this wet land the settler began to devise means to carry off this surplus water. He succeeded until there are only two or three swamps that have not yielded to his labor. Throughout the wooded portion of the township are low places which collect the spring rains and hold the water far into the summer, but only one large swamp remains, that is known as the "big swamp.' It is about a mile long and one-fourth of a mile wide at its greatest width. It is now covered with a tangled growth of vines, willows and soft maples. It was formerly covered with a coarse grass which grew four or five feet high. Each year the farmers plow a little closer to it or put in a new tile ditch so that they are gradually reclaiming some of the best farming land in the county. This swamp in the spring of the year is a miniature lake, after a heavy rain the water is often four feet deep in places. It abounds in thousands of frogs that can be heard on any mild day in winter. Around the edges chimney crawfish rear their chimneys in great numbers. Wild ducks only occasionally visit it, but snipe are common.

This swamp was formerly the home of the beaver. To have an abundant supply of water he built a dam at each end of the swamp. As they exist to-day, they are about seventy to eighty feet in length and four to five feet high. These beavers knew how to economise their labor, because they built their dam at the point where it would require the least work. The water runs out of this swamp in two directions. It is the source of Big Cedar creek that empties into the White Water, and the source of Sand creek which finds its way to the Miami river. When it was the home of the beaver, the water was probably ten feet deep. An open ditch at the south dam is ten feet below the surface; add to this

the height of the dam as it now exists, and it is thirteen feet from the bottom of the ditch to the top of the dam.

The land that has been reclaimed from the swamp is a black vegetable mould that is very productive. Several wells have been made in the reclaimed land that furnish a strong flow of sulphur water, at a depth of four to six feet, out of a pure white sand. The soil is very porous, where it seems perfectly dry, water will soon fill your tracks, and the furrows made by the plow fill with water by the time the farmer can make a second round.

In traveling along the roads the existence of former swamps are very plainly seen. The soil is a grayish or white clay. The decayed vegetable matter in the swamps made a black soil which contrasts strongly with the white clay. Some farms are, however, all black soil. The amount of this soil always determines the value of the land.

The big swamp of late years has completely dried during the long continued droughts, as to the surface appearances, but a stick stuck in the soft loose soil comes out wet, and the hole soon fills with water. The old settlers say that numerous fish could be taken from it during the spring months, when there was plenty of water, and that a tall coarse grass covered it entire during the summer. In the fall, when the grass was dead, it was often fired, when it would burn for weeks at a time, burning great holes in the ground about the edges of the swamp. This swamp is undoubtedly of glacial origin, and formerly extended over more or less of Bath Township. It has been the home of the beaver. It is underlaid with pure white sand and furnishes abundance of sulphur water. Man has labored for seventy years to redeem it, and has almost conquered, making the wilderness blossom as the rose.

WATER CULTURE METHODS WITH INDIGENOUS PLANTS. BY D. T. MACDOUGAL.

During the course of some extended experiments relative to the general nature and functions of the tuberous formations on the roots of Isopyrum it was found impossible to secure a normal development of this hardy plant in pots with customary greenhouse temperature. An examination of the habit of the plant reveals the fact that it starts into active growth at the close of the winter season, when the soil is scarcely above the freezing point, and by the aid of a few days of warm sunshine accomplishes its yearly growth, during a period when the difference between the soil and air temperature is greatest. The amount of such difference between the soil of a northern hillside and the air in April and May, the growing period of the plant, is very great in this latitude, 45°. With such facts in hand

it was easily interpreted that the discoloration and loss of leaf by the plants in the greenhouse was the direct effect of an abnormal absorption of water induced by the unaccustomed high temperature acquired by the small quantities of soil in the pots. The attempt was made to give the plant more nearly the normal conditions of temperature, and at the same time grow it in culture solutions. Since it is found in very moist localities the latter condition offered no violent changes to the habits of the plant. Ordinary culture jars of a capacity of one liter, provided with zinc tops, were used. The diageotropic rhizomes were imbedded in asbestos fibre in a sunken chamber in the zinc tops in such manner that the fibrous roots depended into the fluid beneath. The jars were set their full depth in a roomy box full of porous soil. By means of a constant drip from a water tap the earth was kept saturated, and by reason of the initial low temperature of the water and the rapid evaporation the fluid substance was kept quite cool. So nearly does this meet the natural conditions of the plant that specimens several years old were lifted from the soil in the woods and successfully grown by this method. The writer now has several plants which have been under such treatment during a period of nine weeks. They are of normal size and stature, and at this date (December 18) exhibit a number of flowers, opening buds and maturing seeds, while the development of the roots can be followed with the greatest ease. This method has been used by students in water culture experiments with the cultivated plants very successfully, and by its use it has been found possible to bring under continuous observation during the winter season several species of hardy native plants. In investigations on material of this kind it is believed it will prove valuable.

WORK SHELVES FOR LABORATORY. BY KATHERINE E. GOLDEN.

These are shelves which were constructed in such a manner as to do away with all vibrations from the floor and walls. This object was attained by the use of iron pipe. Round holes were cut through the floor, through which were driven two iron pipes, two and one-half inches diameter, into the ground beneath to a depth of about three feet. If the ground were very firm, a lesser depth would do. The pipes were left a convenient height above the floor. Heavy planks had holes bored in the two ends, through which the pipes fitted closely, the planks being held firmly in position by means of clamps placed beneath them. By means of the clamps the height of the shelves can be varied at any time to suit one's convenience. This kind of shelf is preferable to that which is suspended from the walls of a building, as the latter vibrates with the building.

One pipe would be sufficient for a small table, so that one might thus utilize a small corner of a room. Pipes driven into the ground are, of course, practicable only when the laboratory is on the ground floor and does not require too great an extent of the pipe above the ground.

The special features of these shelves are their cheapness, the carrying of a number of shelves on the same pair of pipes, and the ease with which they can be fixed up, so that one might readily set up shelves for different pieces of apparatus.

I use the shelves for work where a plant is on a lower level than the apparatus used with it. This result is gotten by boring a hole through the shelf and fastening the rod of a ring-stand in the hole with a nut. The ring can then be adjusted to any height on the rod.

New Apparatus for Vegetable Physiology.

By J. C. Arthur.

[Abstract.]

Figure 1. Respiration Apparatus.

The following apparatus was described: (1) A respiration apparatus to determine the amount of carbon dioxide exhaled by breathing plants within a certain time at a fixed temperature, the baryta method being used; (2) a centrifugal apparatus for revolving growing plantlets at a high speed, to replace gravity with a similar force, that may be varied at pleasure, in order to determine its effect in giving direction to the forming organs of plants; (3) a gas chamber to supply different gases to living tissues under the microscope; (4) a slide with binding posts to convey a current of electricity through living tissues under the microscope; and (5) a hygrometer to exhibit the comparative rate of evaporation of water from the two sides of a leaf. An instrument of each kind was exhibited, except the first one mentioned, which was illustrated with a drawing.

1. The Respiration Apparatus consists of a small glass chamber in which the seeds or other growing parts are placed.

This is suspended by means of a brass cover, in an outer jar containing water of suitable temperature. The respiration chamber is connected through potash bulbs and a wash bottle with an aspirator, so that to begin with, all carbon dioxide may

be removed from the chamber and afterwards a current of air free from carbon dioxide be forced slowly through the chamber. As the air leaves the chamber it passes through a long Pettenkofer baryta tube. containing a solution of barium hydrate, and then through a similar but smaller tube, also containing barium hydrate. Only one long and one short tube are used at a time. When the first period is ended the current of air is diverted to the other pair of tubes by the turn of a stopcock, and in the meantime the first pair of tubes is emptied, refilled with fresh solution and placed in readiness to be used when the second period is ended, and so on. The solution from the tubes is titrated, and by a simple calculation the amount of carbon dioxide exhaled by the plantlets ascertained for each period.

The apparatus is a modification of the one used by Prof. Pfeffer (Unters. Bot. Inst. zu Tübingen, I, 637), which in turn was an adaptation of Prof. Pettenkofer's apparatus for studying the respiration of animals.

2. THE CENTRIFUGAL APPARATUS is to illustrate Knight's famous experiment in geotropism. The essential part of the apparatus consists of a closed chamber kept moist by dripping water, in which a cork disk is made to revolve. On this disk are pinned germination seeds. This disk is revolved rapidly (from one hundred to five hundred revolutions a minute) for some time, and the position assumed by the growing roots and the stems observed. The moist chamber and revolving disk may be set horizontally, vertically or at any intermediate angle. The speed is found by moving a paper over a pencil point at the lower end of the spindle for a definite time. It may be run by any convenient power, as a small water motor, or an electric motor. The apparatus is an invention of the writer.

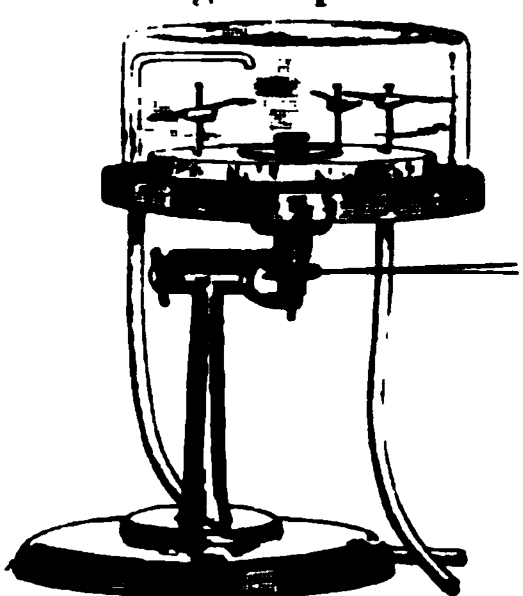


Figure 2. Arthur Centrifugal Apparatus.

3. THE GAS CHAMBER, for use on the stage of the microscope, consists of a shallow brass chamber, three inches long by one and three-fourths broad, with projecting metal tubes at either end. One side of the chamber is provided with a glass window, and the opposite side has a circular opening, which is to be closed when in use with the cover glass bearing the object for the experiment. The object to be examined is placed in a drop of water upon the center of the cover glass. The glass is then inverted over the opening of the gas stage, the margin having first been smeared with vaseline in order to

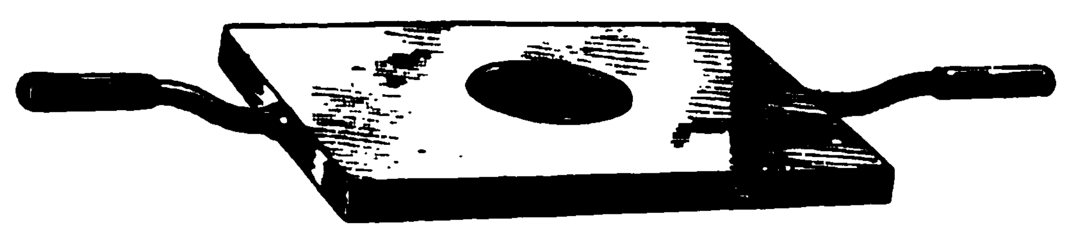


Figure 3.

make the glass fit air tight to the metal. The gas is now passed into the chamber from a generator or reservoir through one tube, escaping through the other. The apparatus has been in use some time in European laboratories.

4. THE GLASS SLIDE WITH BINDING POSTS, to be used when it is desired to pass an electric current through a microscopic object, consists of the usual form of microscopic slide, with a small brass binding post at either end, connected with a pair of clips. To put into use, two small wedge-shaped pieces of tin foil are placed under the clips, so that the points nearly touch. The object is then mounted between them and covered with a cover glass in the usual manner.

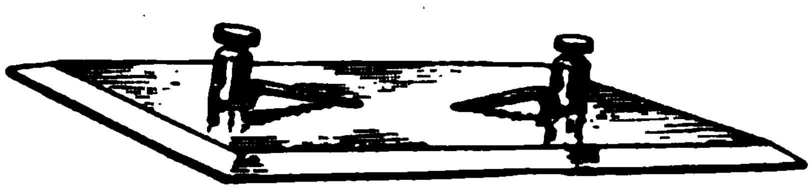


Figure 4.

5. THE AWN HYGROMETER is used to indicate the loss of moisture from a leaf surface. It consists of a thin glass chamber, across the mouth of which extends an adjustable metal rod. An awn of stipa is supported from the middle of the rod by a set screw, and from the other end of the awn an index projects at right angles. As the air of the chamber becomes moister the awn untwists, and the index is carried around. The most satisfactory way of using this instrument is to fasten a pair of hygrometers of equal sensitiveness to a leaf, one on either side, by means of a mixture of wax and oil. The leaf is either left attached to the plant or dipped into water to prevent wilting, as shown in figure 5a. The comparative rate of transpiration from the upper and lower surfaces of a leaf is thus obtained.

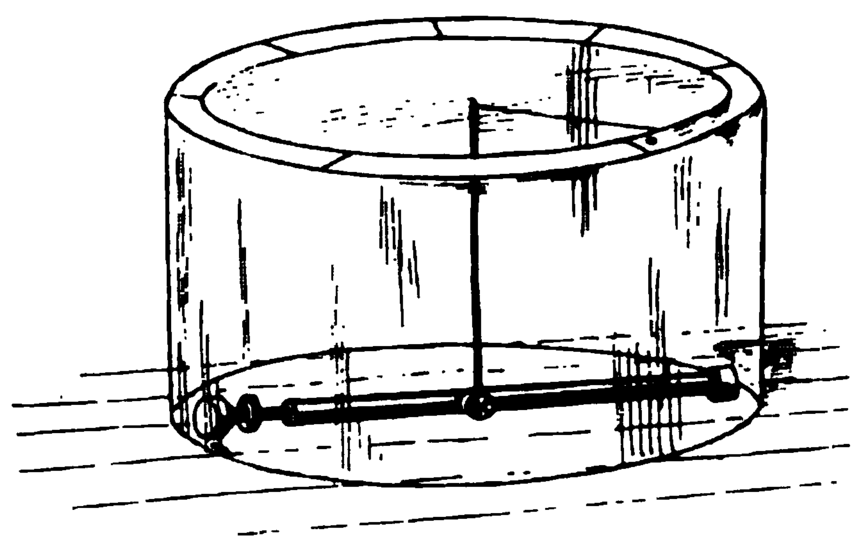


Figure 5. Darwin Awn Hygrometer.

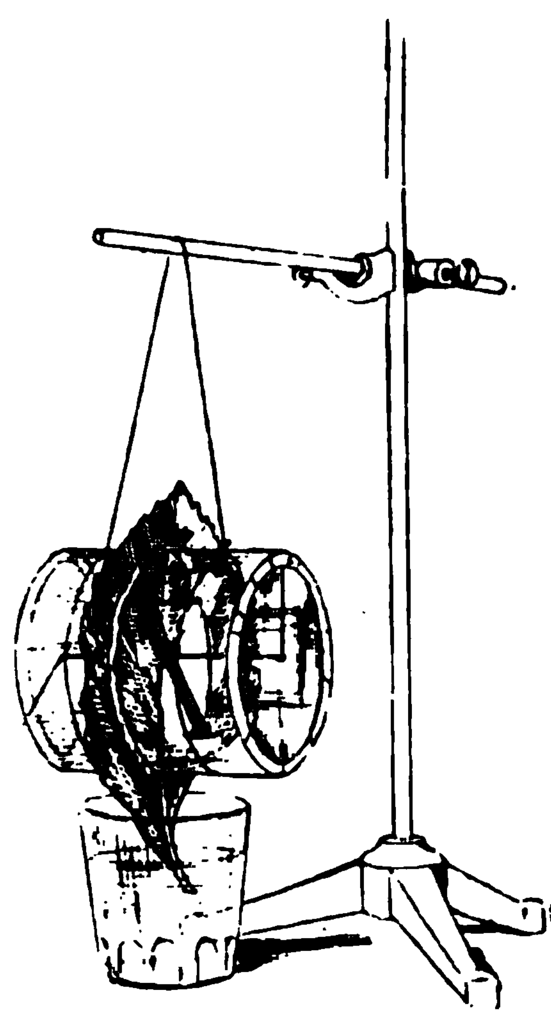


Figure 5a. Hygrometer in Use.

This instrument in the crude form was seen by the writer when visiting the laboratory of Mr. Francis Darwin at Cambridge in 1888, and has been in use in the physiological laboratory of Purdue University since that time. The present form is the result of this experience.

COLLECTIONS OF PLANTS MADE DURING 1894. BY M. B. THOMAS.

It was thought that it might be of some interest to those working in various parts of the State upon the Biological Survey, to hear regarding the botanical work that has been accomplished in and about Crawfordsville during the past year. In connection with the regular required work of the senior year, the students are expected to devote much of their time, especially during the last term, to the preparation of papers upon some special topics. The results of this work last year were presented to the Academy in a short paper, and it is the purpose of this abstract to add a few notes regarding the additions that have been made during the year to the material that will ultimately enable us to obtain a fairly comprehensive knowledge of the forms of plant life in our region. It must be recognized that much of the work, covering as it does a wide range of subjects, can not be pushed with the speed or exhaustiveness that would be desired, but since in all cases material is preserved and stored away with accurate and complete notes, it will in time leave but examination and ultimate determination, an easy task in comparison with the laborious work of systematic collection and preliminary determination.

One of the subjects upon which faithful and earnest work was done included a study of the trees and shrubs of our flora. This work was carried on by Mr. L. M. Gentry, and his painstaking efforts resulted in quite a large list of these plants to our region. His tabulated statements show, collected up to June 20, 116 species and varieties of trees and shrubs, representing twenty-seven orders and sixty-seven genera. This, when compared with the whole number already reported in the state, will be seen to be quite a goodly representation for so small an area. By a careful system of taking notes and marking trees, a record is preserved of each locality to assist in further studies.

The next subject of interest was the work on the mosses of our region, by Messrs. C. Gentry and E. W. Olive. Careful collections were made and the material studied very faithfully, but it is expected since the determination of species was done without any great supply of literature and no herbarium for comparison, that some inaccuracies in naming will appear when the material is submitted for final examination. The list, however, shows thirty species, representing nineteen genera.

The other problem of a systematic character undertaken by the students was carried on by Mr. Tom Moore, and was a study of the filamentous algæ. Comparatively nothing upon this subject has been published from this state, and the work started by Mr. Moore was almost pioneer in this locality. Notwithstanding

the difficulties at present in the way of a systematic arrangement of the species of this group, because of the uncertainties in regard to the position of certain forms, Mr. Moore very carefully identified and preserved about twenty species. This represents a very small number of the forms studied, and as the work is now being continued by him under Dr. Farlow's direction at Cambridge, it is expected that some substantial record may be made to this part of our flora.

The list of parasitic fungi reported from our vicinity has been increased by Mr. Olive, much of it during the class work in this subject, until we now have 175 species and 250 hosts, twenty-seven species and forty-three hosts being new to the list published in the proceedings of last year. About forty species yet remain to be determined.

Work in the phanerogams has been continued and 204 species added to our local list. These do not include those in the report of Mr. Gentry on trees and shrubs.

The local list of pteridophytes now amounts to *nineteen*. We are yet far from the desired condition, but yearly additions are giving us better insight into our flora and enabling us to work to far better advantage than heretofore.

THE FLOWERING PLANTS OF WABASH COUNTY. BY A. B. ULREY AND J. N. JENKINS.

REVISION OF THE PHANEROGAMIC FLORA OF THE STATE. BY STANLEY COULTER.

[ABSTRACT.]

A review of work done during the year, including list of families studied in detail, collections examined, with presentation before Academy of work as far as completed. Suggestions were also offered concerning collection of certain forms in which existing herbaria were strikingly deficient.

REPORT OF THE BOTANICAL DIVISION OF THE INDIANA STATE BIOLOGICAL SURVEY FOR 1894. BY LUCIEN M. UNDERWOOD.

[ABSTRACT.]

Account of work in the field accomplished by the survey during the year. Necessity of having an organized body of correspondents throughout the state. Issue of *exsiccatæ*, with terms of distribution. Statement of work on the higher flora. Difficulties inherent in the collection of the lower plants. Acknowledgments.

An Increasing Pear Disease in Indiana. By Lucien M. Underwood.

[Abstract.]

Septoria piricola Desm., was first collected in the state by Dr. J. C. Arthur, in Tippecanoe County, in September, 1892. It was collected by the writer in Putnam County in October of the same year. Since that time its ravages are on the increase, and it has been seen in a number of pear orchards in central Indiana. The disease appears early in the summer and continues as long as the leaves remain on the trees. It manifests itself in the form of a series of brownish spots on the leaf where the chlorophyll-bearing tissue is destroyed by the fungus. On many leaves examined from one-fifth to one-half of the leaf was diseased. The effect was seen in the utter failure of the tree to produce fruit. In many cases it would be difficult to find a single leaf on a tree that was unaffected. It is evidently a good opportunity to introduce spraying with the usual Bordeaux mixture.

Value of Seed Characters in Determining Specific Rank.

The purpose of this study was to see if sufficient differences existed in the seeds of plants to enable us to determine specific rank. The plants taken for this work were those of the family *Plantaginaceæ*, including the ordinary plantain. The seeds were examined as to color, shape, size, and character of surface. The seed coats were also studied to see if histological differences of classificatory value existed, while incidentally any striking features in cell contents or peculiarities in response to the action of various reagents were noted.

The seeds were first studied as to external characters, and it was found that according to color and surface they could be separated into three groups: *P. major*, *decipiens* and *eriopoda* being black; *P. maritima*, *Patagonica*, *pusilla* and *cordata*, brown, and *Virginica* yellow. By outline of cross section it was found that they could be separated into four groups. By the combination of these two groupings we find that each species has at least one characteristic that is not found in any of the others. *Virginica* and *Patagonica* resemble in cross section, but differ in color; *major* is easily distinguished by outlines; *pusilla* is different from all others in cross section; *major* and *cordata* resemble in cross section, but are distinguished by color and surface; *decipiens* and *eriopoda* are similar in cross section and color, but differ in the position of the hilum.

The seed coats are somewhat diverse in structure, showing five general types, but after comparing the results in all cases it is apparent that the species examined do not show sufficient differences to enable us, in all cases, to distinguish one from another. For while the seed coat of one species may be unlike all

others, and, therefore, readily distinguished, yet the second may be precisely like the third, thus rendering the seed coat valueless, on the whole, as a means of determining specific rank.

After a careful comparison of the results reached through these experiments, it is safe to say that the same harmony of structure exists in the seeds of species as in the leaf or the flower, while the same variety is found existing between seeds of different species. For although in the family under discussion each species resembles one or more of the others in some respects, yet it has at least one characteristic that is peculiarly its own. Thus *major* resembles *decipiens* in color, but differs from all the others in outline. *Virginica* and *Patagonica* are similar in cross section, but differ in color. And so on through the list studied, one may be distinguished by outline, another by color, another by cross section, or another by surface, yet the individual seeds of any one species are "as like as two peas." By these results we are impelled to the belief that the characteristics of seeds furnish as true an index to family, genus or species as do the leaf and the flower; and that it only remains for the botanist to school himself to read aright the lessons found in nature to be convinced that nothing is left to chance or accident, but that she has mathematical rules and chemical formulæ to which she is as constant as the needle to the pole.

Additions to the Fish Fauna of Wabash County. By W. O. Wallace.

Notes on Reptilian Fauna of Vigo County. By W. S. Blatchley.

Preliminary List of the Birds of Brown County. By E. M. Kindle.

Brown County lies about forty miles south of Indianapolis. Its boundaries correspond rather closely with natural features, and it may consequently be regarded as representing much more closely than counties usually do a faunal area. It has the geological distinction of being the only county in the state whose limits are confined entirely to the knobstone formation. The limestone hills of Monroe County approach to within a mile or two of the western boundary, while on the north and east, the southern limit of the drift corresponds approximately to the boundaries separating it from Morgan, Johnson and Bartholomew Counties. The county has a uniformly rugged and broken surface, which reaches the maximum

of elevation in Bear Wallow and Weed Patch hills. Much of the county is still heavily timbered or covered with dense underbrush. The entire absence of ponds and marshes and of any large streams offers no inducement to water-loving birds to stop within the county. Bean Blossom and Salt Creek, which drain the county, are both small and unimportant streams.

The present list makes no pretension to being complete. It is offered as a first contribution to the ornithology of the county, which may serve as a basis for future work. The observations on which it is based have been made mainly in the course of several excursions to the county during the past three years. For the notes on nesting and the dates of first arrival of some migratory species I am indebted to Mr. Victor Barnett, a careful resident observer. Only those species are noted as breeding that have been observed nesting.

The list includes 106 species. Summarizing the more important facts concerning these species in their relation to the county, I find there are resident species 22, summer residents 47, winter residents 4, migrants 27. Fifty-three of these species are known to breed within the county.

My observations have not, perhaps, been sufficiently extended to warrant any remarks on species which do not occur in the county that might have been expected. I have, however, been much surprised at the apparent absence of one species, the summer red bird, inasmuch as it is common in Monroe County a few miles west of the Brown County line.

1. *Ardea virescens.* Green heron. A common summer resident.

2. *Rallus elegans.* King rail. Rare migrant.

3. *Philohela minor.* American woodcock. Old one with four young seen April 13, '94 (Barnett).

4. *Gallinago delicata.* Wilson's snipe. Migrant. March 24, '94.

5. *Totanus solitarius.* Solitary sandpiper. Common migrant.

6. *Ægialitis vocifera.* Killdeer. Summer resident. Breeds.

7. *Colinus virginianus.* Bob White. Common resident.

8. *Bonasa umbellus.* Pheasant. Common resident.

9. *Meleagris gallopavo.* Wild turkey. Almost if not entirely extinct. Formerly abundant.

10. *Ectopistes migratorius.* Passenger pigeon. Rare migrant. March 7, '94.

11. *Zenaidura macroura.* Turtle dove. Rather common resident.

12. *Cathartes aura.* Turkey vulture. Common summer resident. Breeds.

13. *Buteo borealis.* Red-tailed hawk. Common resident. Breeds.

14. *Haliæetus leucocephalus.* Bald eagle. An occasional visitor.

15. *Falco sparverius.* Sparrow hawk. Common summer resident. Breeds.

16. *Pandion haliaëtus carolinensis.* Fish hawk. Rare migrant. March 8, '94.

17. *Syrnium nebulosum.* Barred owl. A rather common resident.

18. *Megascops asio.* Screech owl. Very common resident.

19. *Conurus carolinensis.* Carolina paroquet. It is reported to have been formerly abundant along Bean Blossom by old settlers.

20. *Coccyzus americanus.* Yellow-billed cuckoo. A common summer resident. Breeds.

21. *Coccyzus erythrophthalmus.* Black-billed cuckoo. Rare.

22. *Ceryle alcyon.* Belted kingfisher. Common summer resident. Breeds.

23. *Dryobates villosus.* Hairy woodpecker. Common resident.

24. *Dryobates pubescens.* Hairy woodpecker. A more common resident than the preceding.

25. *Sphyrapicus varius.* Yellow-bellied woodpecker. A regular migrant. February 20, '94.

26. *Ceophlœus pileatus.* Pileated woodpecker. A rare resident.

27. *Melanerpes erythrocephalus.* Red-headed woodpecker. An abundant summer resident. Sometimes common in winter.

28. *Melanerpes carolinus.* Red-bellied woodpecker. Rather common resident.

29. *Colaptes auratus.* Yellow hammer. Common summer resident.

30. *Antrostomus vociferus.* Whip-poor-will. Summer resident. Breeds. April 16, '94.

31. *Chordeiles virginianus.* Night hawk. Abundant migrant. May 9, '94.

32. *Chaetura pelagica.* Chimney Swift. Common summer resident.

33. *Trochilus colubris.* Ruby-throated humming-bird. Common summer resident. May 2, '94.

34. *Tyrannus tyrannus.* King bird. Common summer resident. Breeds. April 18, '94.

35. *Myiarchus crinitus.* Great crested fly-catcher. Common summer resident. Breeds. April 28, '94.

36. *Sayornis phœbe.* Pewee. A common summer resident. March 10, '94.

37. *Contopus virens.* Wood pewee. Common summer resident. Breeds. May 4, '94.

38. *Empidonax flaviventris.* Yellow-bellied fly-catcher. One specimen taken on Weed Patch Hill August 11, '91.

39. *Otocorys alpestris praticola.* Prairie horned lark. A rather rare resident Breeds. Common in flocks in winter.

40 *Cyanocitta cristata.* Blue jay. A common resident.

41. *Corvus americanus.* American crow. Abundant resident.

42. *Dolichonyx oryzivorus.* Bobolink. Rare migrant. May 3, '94.

43. *Molothrus ater.* Cow bird. Common summer resident.

44. *Agelaius phœniceus.* Red-winged black-bird. Summer resident. Breeds. March 7, '94.

45. *Sturnella magna.* Meadow lark. Abundant summer resident. March 2, '94.

46. *Icterus spurius.* Orchard oriole. A common summer resident. Breeds. It migrates soon after the young are out of the nest.

47. *Icterus galbula.* Baltimore oriole. Rare.

48. *Scolecophagus carolinus.* Rusty blackbird. Migrant. March 14, '94.

49. *Quiscalus quiscula æneus.* Crow blackbird. Common summer resident. Breeds. March 6, '94.

50. *Carpodacus purpureus.* Purple Finch. Migrant. April 24, '94. A pair taken December 15, '94.

51. *Spinus tristis.* Thistle bird. A common summer resident.

52. *Poocætes gramineus.* Vesper sparrow. An abundant summer resident. Breeds. March 13, '94.

53. *Ammodramus sandwichensis.* Savanna sparrow. Migrant. April 29, '94.

54. *Ammodramus savannarum passerinus.* Grasshopper sparrow. Summer resident. Breeds. March 29.

55. *Chondestes grammacus.* Lark Sparrow. Rather a common summer resident. April 18, '94.

56. *Zonotrichia leucophrys.* White-crowned sparrow. A common migrant. April 28, '94.

57. *Zonotrichia albicollis.* White-throated sparrow. Abundant migrant in April and November.

58. *Spizella monticola.* Tree sparrow. An abundant winter resident.

59. *Spizella socialis.* Chipping sparrow. A common summer resident. Breeds. March 20, '94.

60. *Spizella pusilla.* Field sparrow. An abundant summer resident. Breeds. March 9, '94.

61. *Junco hyemalis.* Snow bird. An abundant winter resident.

62. *Melospiza fasciata.* Song sparrow. A common resident.

63. *Passerella iliaca.* Fox sparrow. A common migrant. March 6, '94.

64. *Pipilo erythrophthalmus.* Towhee. A common resident.

65. *Cardinalis cardinalis.* Red bird. A common resident.

66. *Habia ludoviciana.* Rose breasted grosbeak. Migrant. April 29, '94.

67. *Passerina cyanea.* Indigo bird. Abundant summer resident. Breeds. April 29, '94.

68. *Spiza americana.* Dickcissel. Common summer resident. Breeds. May 12, '94.

69. *Piranga erythromelas.* Scarlet tanager. Summer resident. April 29, '94.

70. *Progne subis.* Purple martin. Common summer resident. Breeds.

71. *Chelidon erythrogaster.* Barn swallow. Common summer resident. Breeds. April 17, '94.

72. *Lanius borealis.* Northern shrike. A rather rare winter resident. Two were taken November 18, '94.

73. *Lanius ludovicianus excubitoroides.* White rumped shrike. Migrant. March 13, '94.

74. *Vireo olivaceus.* Red eyed vireo. Common summer resident. Breeds. April 29, '94.

75. *Vireo noveboracensis.* White eyed vireo. Common summer resident. Breeds. April 27, '94.

76. *Vireo flavifrons.* Yellow throated vireo. Migrant. Taken once April 19, '94.

77. *Helmitherus vermivorus.* Worm eating swamp warbler. April 29, '94.

78. *Helminthophila pinus.* Blue winged yellow warbler. Common summer resident. April 29, '94.

79. *Dendroica æstiva.* Summer warbler. Common summer resident. April 4, '94.

80. *Dendroica cærulescens.* Black throated blue warbler. Migrant. Rare. May 13, '94.

81. *Dendroica coronata.* Yellow rumped warbler. Abundant migrant. April 14, '94.

82. *Dendroica palmarum.* Red poll warbler. Common summer resident. April 23, '94.

83. *Seiurus aurocapillus.* Oven bird. Rare summer resident. May 5, '94.

84. *Geothlypis trichas.* Maryland yellow throat. Common summer resident. Breeds.

85. *Icteria virens.* Yellow breasted chat. Common summer resident. Breeds.

86. *Sylvania mitrata.* Hooded warbler. Summer resident. Not common. April 30, '94.

87. *Sylvania canadensis.* Canada warbler. Migrant. May 24, '94.

88. *Anthus pennsylvanicus.* American titlark. A common spring migrant.

89. *Mimus polyglottus.* Mocking bird. One specimen taken March 10, '93, by Victor Barnett, near Bean Blossom Creek.

90. *Galeoscoptes carolinensis.* Cat bird. Common summer resident. April 23, '94.

91. *Harporhynchus rufus.* Brown thrasher. Common summer resident. Breeds. March 23, '94.

92. *Thryothorus ludovicianus.* Carolina wren. Resident. Not very common.

93. *Troglodytes aëdon.* House wren. Common summer resident. March 16, '94.

94. *Troglodytes hiemalis.* Winter wren. Winter resident. Not common.

95. *Certhia familiaris americana.* Brown creeper. Common migrant. March 31, '94.

96. *Sitta carolinensis.* White bellied nuthatch. Common resident.

97. *Sitta canadensis.* Red bellied nuthatch. Common migrant.

98. *Parus bicolor.* Tufted titmouse. Common resident.

99. *Parus carolinensis.* Black capped chickadee. Common resident.

100. *Regulus satrapa.* Golden crowned kinglet. Common migrant. March 22, '94.

101. *Regulus calendula.* Ruby crowned kinglet. Migrant. April 18, '94.

102. *Polioptila cærulea.* Blue gray gnat catcher. Common summer resident. Breeds. April 17, '94.

103. *Turdus aliciæ.* Gray cheeked thrush. Summer resident. April 14, '94.

104. *Turdus aonalaschkae pallasii.* Hermit thrush. Common migrant. April 15, '94.

105. *Merula migratoria.* American robin. Abundant summer resident.

106. *Sialia sialis.* Blue bird. Abundant summer resident.

Notes on the Birds of 1894. By A. W. Butler.

In the study of the birds of our state, one steps over the boundary in many instances. On the south, the bird fauna is influenced by the Ohio River. On the east, the Big Miami and St. Joseph and St. Mary's rivers have some relation to bird life; on the north, Lake Michigan, with its tributaries, plays an important part in bird distribution; and on the west the Wabash and its western tributaries, besides the lower Kankakee, affect the distribution of birds both in Illinois and Indiana. The reports of occurrence of the migrations and of the breeding of birds without our state may thus be of value in the study of our own birds. This

is particularly true in the State of Michigan. From the fact that it lies immediately north of us, many of its migratory birds may pass through this State. So, this year, I am enabled to present several notes on birds from without the State that have an important bearing upon the study of the birds of this State.

1. *Ammodramus henslowii* (Aud.). Henslow's sparrow.

Last year I reported the common occurrence and breeding of this species at English Lake, Indiana. At that time it had not been taken in Michigan. The first record from that State is given this year. May 12, 1894, Mr. L. Whitney Watkins reported six from Manchester, Mich. May 30, a nest containing five eggs was found in Jackson County, Michigan. The bird could not be identified. June 8, the female was shot as she was leaving the nest and proved to be this species. The locality was an open marsh bordering a lake. The nest was neatly though loosely constructed of coarse grasses and sedges lined with finer ones. It was situated in a tuft of grass about four inches above the wet ground. The eggs average .72 x .59 in., and were white with small reddish specks so numerous as to form an imperfect wreath about the larger end. Nest was hardly different from one of Maryland yellow-throat found in the same locality on the same day. Incubation nearly complete. An account of the breeding of the species as above noted has appeared in a number of the Nidiologist.

Mr. J. O. Dunn, of Chicago, found Henslow's sparrow very common at Bass (formerly Cedar) Lake, Starke County, Ind., late in July, 1894. They were apparently breeding, though no nests were found. One beautiful, clear evening, about 10:30 o'clock, Mr. Dunn says he heard one of these birds singing near camp. Thus we have another added to the voices of the night.

2. *Thryothorus bewickii* (Aud.). Bewick's wren.

In 1880 this species had not been reported north of Vigo, Putnam and Marion counties, in this State. May 1, 1894, Mr. G. G. Williamson reported one from Muncie, and he again noted it May 9. Messrs. L. A. and C. D. Test, of Lafayette, report it at that place April 12, 1894. They say it is tolerably common and breeds. Mr. W. O. Wallace informs us that he saw them at Wabash, Ind., April 23-25, April 25, April 27 and June 1, 1894. He notes them as abundant there. Mr. Jerome Trombley, Petersburg, Mich., reports one May 15, and again May 16, at that place. He says they are rare and breed. Mr. E. J. Chansler, Bicknell, Knox County, Ind., says it is a common summer resident. Perhaps some winter. Appear to be getting more numerous. Breeds. Thus will be noted further evidence of the rapid extension of the summer range of this species, and of its increase in numbers in localities where it has previously appeared.

3. *Charadrius squatarola* (Linn.). Black-bellied plover.

A rare migrant. Mr. J. E. Beesley reports two from Lebanon, Ind., the past spring; one May 3d, the other May 5th. Mr. Fletcher M. Noe reports one killed near Indianapolis, May 30, 1894, by Mr. C. W. Lambart.

4. *Protonotaria citrea* (Bodd.). Prothonotary warbler.

Lebanon, Ind., May 23, one. May 29, 1894, rare. (Beesley.)

5. *Calcarius pictus* (Sw.). Smith's longspur.

Mr. J. O. Dunn informs met that he found a specimen in a game store in Chicago from North Illinois. Mr. Jesse Earle, Greencastle, Ind., informs me, on March 29, 1894, in a certain pasture three miles west of Greencastle, he saw probably 60 Painted Longspurs. He collected two. These are the first recorded since Mr. E. W. Nelson found them common in Lake County, Ind., and Cook County, Ill., in 1875.

6. *Icteria virens* (L.). Yellow-crested chat.

Taken at Ann Arbor, Mich., spring of 1894, by A. B. Covert (Watkins, L. W.). Petersburg, Mich., two, May 3; two, May 17, 1894. Rare. Two nests found. Has not been noted here before since 1877. (Jerome Trombley.) Dunreith, Henry County, Ind., June 7 and 12, 1894, rare. (E. Pleas.)

7. *Branta canadensis hutchinsii* (Sw. and Rich.). Hutchins' goose.

Mr. E. J. Cransler says they are rare and seldom seen. They were quite common the winter of 1893. Could be seen in large flocks in company with Canada goose. He saw a large flock of Hutchins' geese in Gibson County in 1891. According to Dr. Brayton they were formerly common and bred in the State. (Trans. Ind. Hort. Soc. 1879, p. 178.) Not recently reported.

8. *Guara alba* (Linn.). White ibis.

Knox County, rare. An uncle of mine killed a bird of this species more than fifty years ago. Dr. Smith, of Bicknell, says he killed one in 1864.

9. *Catharista atrata* (Bartr.). Black vulture, carrion crow.

Knox County. Resident. Have become common since 1889. Previous to that date were seldom seen. They must breed, as they are present all the time. Quite common this fall, as there were many dead hogs for them to feed upon. (Chansler.)

10. *Elanoides forficatus* (Linn.). Swallow-tailed kite.

Knox County. Rare summer resident. I saw one in August, 1890, its mate was killed the day before and is now preserved by Mr. J. Freeman, Bicknell, Ind. April 11, 1894, one was seen by Mr. Harbin. (Chansler.)

11. *Conurus carolinensis* (Linn.). Carolina paroquet.

Knox County (?), Daviess County. Formerly a resident. My grandmother told me they were yet to be found about Grassy and Swan Ponds in Daviess

County in 1859. A neighbor of mine makes a similar statement. Another person says they were still found in Knox County and Daviess County in 1857–58. They say they flew in flocks arranged along two sides of a triangle after the manner of wild geese. They built their nests and roosted in woodpecker's holes or hollow trees. When roosting, it is claimed they hung suspended by their bills. They laid but two eggs. They remained about rivers, swamps and ponds. They lived almost entirely on cuckle-cockle burrs. One man said they would pile the burrs upon stumps, and after hulling out the kernel leave the empty burrs in a pile. They visited the orchards and did not injure the fruit trees as badly as generally claimed. (Chansler.) Mr. E. R. Quick informs me that Mrs. Laforge, an old lady who recently died, told him that she knew the paraquets quite well in Franklin County. She referred to the habit which she said was common, of splitting open apples with their bills in order to get the seeds for food, discarding the remainder of the fruit.

12. *Cistothorus stellaris* (Licht.). Short-tailed marsh wren.

July 24, 1894, Mr. Alexander Black obtained two of these birds from the reedy shore of the mill pond near Greencastle, which has become noted for the rare forms along its banks. He suspected a nest was hidden among the reeds. Next morning he continued his search and found the nest. This is the third breeding record for our state.

13. *Porzana jamaicensis* (Gmel.). Black rail.

July 27, 1894, Jesse Earle and Alexander Beach identified the black rail among the saw-grass about the "mill pond," Putnam County, Ind. It ran, but could not be induced to take wing, and finally hid. July 28, the bird was again seen, but could not be flushed. Although searched for, it could not be found until July 31. Then by the aid of a pointer dog it was flushed, but not shot. August 1, the dog caught a bird which proved to be a young black rail, too small to fly. Continuing the search an adult of the same species was flushed and secured. It was a male. This is the second account of its occurrence in the state, and the first account of its breeding. The same day a Virginia rail was caught, the first for that county.

14. *Xanthocephalus xanthocephalus* (Bp.). Yellow-headed blackbird.

Elkhart County, reported by Chancey Juday, from Millersburg.

15. *Spizella pallida* (Sw.). Clay-colored sparrow.

Several specimens taken by L. Whitney Watkins, September 3, 1894, at Manchester, Mich. There were about forty seen. But two former occurrences in that state are recorded. In Indiana it has been taken but once, September 27, 1890, at Terre Haute, Ind., by Professor W. S. Blatchley and reported by him at the meeting of this Academy in 1890.

16. *Ardea cærulea* (Linn.). Little blue heron.

Knox County summer resident; breeds. Saw one May 4, 1894. Mr. Harbin saw one on White River, June 5, 1894. Very shy (Chansler).

17. *Ardea candidissima* (Gmel). Snow heron.

Knox County summer resident; breeds. I have seen hundreds of these birds about the Swan and Grassy Ponds of Daviess County. They are often in company with the great blue heron.

18. *Ardea tricolor ruficollis* (Gosse). Louisiana heron.

Reported by Mr. E. J. Chansler, from Knox County. Second record from the state.

19. *Campephilus principalis* (Linn.). Ivory-billed woodpecker.

Mr. Harbin claims to have killed one in 1880. Reported by Mr. Warren from Southern Gibson County in 1893. (Chansler).

20. *Nyctea nyctea* (Linn.). Snowy owl.

Mr. Fletcher M. Noe reports receiving a fine snowy owl which was killed at Southport, Ind., six miles south of Indianapolis, November 18, 1894.

21. *Ardetta neoxena* (Cory.)

The capture of this rare species in Michigan the past summer, and the possibility of its occurrence in Indiana, make it worthy of special reference here. There were but nine specimens known.

1. The species was decribed from the Okeechobee Region, Fla. No date given. The Auk, Vol III., Apr., 1886, p. 262.

2. July 9, 1889. Thirty miles south of Lake Okeechobee. By Capt. J. F. Menge. He reported seeing three specimens, of which he was only able to get one The Auk, Vol. VI., Oct. 1889, pp. 317–318. In the same magazine is given Mr. Menge's account of the nest of the species found in the same locality, June 8, 1890.

3. May 18, 1890, in marsh near Toronto, Ont. Specimen now in collection, Canadian Institute. McIlwaith Birds of Ontario, 18, pp. 109–110.

4. May 19, 1890. Kissimmee River, Fla. By Mr. R. C. Stewart. The collector claims to have seen another, which he was unable to secure. The Auk, Vol. VIII, July 1891, p. 309.

5. June 28, 1891. Three miles south of Lake Okeechobee River, Fla. Male. By Capt. J. F. Menge.

6. July 15, 1891. Lake Flirt, Fla. By Capt. J. F. Menge.

7. August 15, 1891. Lake Flirt, Fla. By Capt. J. F. Menge. The last three are in the collection of Prof. W. E. D Scott. The Auk, Vol. IX, Apr. 1892, pp. 141–142.

8. May 20, 1893. Female. Toronto, Ont. By J. Ramsden. The Auk, Vol. X, Oct. 1893, pp. 363–364.

9. Aug. 8, 1894. Manchester, Mich. A specimen of this rare species was brought to Mr. L. Whitney Watkins by a neighbor's boy. Mr. Watkins at once wrote me of the peculiar dark Least Bittern that he had received. I suspected its identity and requested that he send it to me for examination. It had, however, been forwarded to Mr. W. B. Barrows, Agl. Coll., Mich. He determined it to be Cory's Bittern. It will be noted that six of those known have been taken in Florida and the other three north of the latitude of the northern boundary of Indiana. The peculiar extent of the range of Kirtland's Warbler, as noted last year before this Academy, finds a somewhat parallel peculiarity in this species.

The bird may be reasonably expected to occur in Indiana. Its dark color gives it the name of "Black Bittern" in Florida, to distinguish it from the "Least Bittern," which is called "Brown Bittern." They are about the same size.

Smith's Longspur, the Short-tailed Marsh Wren and nest, the Black Rail, have been very kindly deposited in my collection to verify the notes.

22. *Saxicola œnanthe.* Wheatear.

A specimen of this species was shot from among a flock of titlarks at Ann Arbor, Mich., October 4, 1894, by Adolphe B. Covert. The specimen is now in the U. S. Nat. Mus., Washington, D. C., No. 135,068, male, immature. (The Nidiologist, Vol. II., No. 3, Nov., 1894, pp. 42–43.)

23. *Anas penelope* (Linn.). Widgeon: European Widgeon.

The European Widgeon has not before been reported from Indiana. The first account of its occurrence is published by Mr. Ruthven Deane, in "The Auk," Vol. XII., April, 1895, p. 179: "The specimen in question was taken on the Kankakee River, at English Lake, Ind., April 13. 1893, by Mr. Landon Hoyt, of Chicago, Ill., and is now in his possession. When shot it was in company with a flock of Baldpates (*Anas americana*)."

The species has occasionally been taken in America, but I think its records in this vicinity are two in Illinois and one in Wisconsin.

24. *Ectopistes migratorius* (Linn.). Passenger Pigeon.

In 1888 Mr. Wm. Brewster visited the parts of Michigan well known as the breeding grounds of these birds. The flight was small, compared with what was reported in former years. They passed north of the lower peninsula to breed. At that time Mr. Brewster was of opinion that there were enough pigeons left to restock the nest, provided they could be protected by adequate laws. Whether or not that can be done is doubtful. If we may judge by the past legislation and its enforcement on behalf of our native game, it seems to me hardly probable that it will be done. The last passage of pigeons that could be dignified with the

name of "flight" occurred in 1877. That fall there were a great many observed about Hanover, Ind. Some notes which have recently come to hand may be of interest. The greater part of them relate to this year:

Manchester, Mich., June 13, 1894. None have been seen before in ten years. Breeds?

September 9 and 12, 1894. L. Whitney Watkins, Spearsville, Ind. One March 7, 1894.

April 5, 1894. Rare.—Victor H. Barnet.

Laporte, Ind., April 10, 1894. Saw flock of fifty or more. First large flock seen in several years.—Charles Barber.

Bicknell, Knox County, Ind. Migrant rare if not extinct. I have not seen one for ten years. They formerly were abundant. I can remember, during their migrations, the heavens would be covered for hours, yes, for days, in all directions with them. They formerly bred near here, and would cover the forests for miles, until the limbs would break down with their weight.—E. J. Chansler, spring, 1894.

Recently I received a letter from the same gentleman, containing the following notes:

"I saw a considerable flock of these birds 1st of September, 1894. Mr. Harbin saw a flock October 5, 1894. These were the first pigeons I have seen for years."

Grand Haven, Mich. One May 3, 1894. Very rare; used to be plentiful. Breeds.—E. Davidson.

Kentland, Ind. Mr. W. W. Pfrimmer says they were formerly very plentiful. Nested in the timber along the Kankakee River. Now scarce. Have seen none for two years. In 1892 I shot two.

Dunreith, Henry County, Ind. Mr. E. Pleas says twenty years ago wild pigeons came in vast numbers almost every spring.

Out of some four reports on the spring migration and ten on those of the fall but five reported the presence of the wild pigeon. A bird so conspicuous that if present could scarcely escape unseen. And even this report is better than for some years past. One pigeon in a year! Think of the change! Within the memory of men who are not yet old these migratory pigeons would obscure the sun and hide the sky for hours, sometimes for days in succession. The strange appearance was made more wonderful by the continuous rumble of the thunders of the oncoming clouds—the noise of the strokes of millions upon millions of wings. Some of the roosts covered many miles of forest. There, as they settled at evening, the gunners from miles around began the slaughter. After a number

of shots over a considerable area, several acres, sometimes the whole roost would rise with a deafening thundering, which no one has attempted to describe, and soar out of sight in the dusk of the early evening, while from the rising cloud came a noise as of a mighty tornado. As the darkness settled the birds descended and alighted many deep upon the limbs of the trees, the weight being so great as to break many off. Then the scene changed. The slaughter began in earnest. The rapid firing of guns, the squawking of the pigeons, the breaking of the limbs of giant trees beneath their living weight, the continuous rumble arising from the whirr of countless wings, all illumined by the lurid lights from many fires, produced an effect which no words can convey to one who has not experienced a night at a "pigeon roost." Each year such scenes were re-enacted. Each year the slaughter went on. Less and less the numbers grew. Trapping and netting, supplemented by repeating guns, added to the power of destruction, and the pigeons, whose numbers were once so great that no one could conceive the thought of their extinction, have dwindled until they are rarely found, until they are only a memory.

Some Notes on the Blind Animals of Mammoth Cave, with Exhibition of Specimens. By R. Ellsworth Call.

The Batrachians and Reptiles of Wabash County. By W. O. Wallace.

On the Occurrence of the Whistling Swan in Wabash County. By A. B. Ulrey.

Birds of Wabash County. By A. B. Ulrey and W. O. Wallace.

Birds Observed in the Sawtooth Mountains. By B. W. Evermann and J. T. Scovell.

Animal Parasites Collected in the State During the Year. By A. W. Bitting.

ANGLING IN THE ST. LAWRENCE AND LAKE ONTARIO. BY BARTON W. EVERMANN.

THE MAMMALS OF INDIANA. BY A. W. BUTLER.

One of the advantages of a work upon the natural history of a region is the opportunity it affords for criticism, correction and for the accumulation of additional material. One's friends after going over the paper will say they had not thought the occurrence of a given species of any importance. They are common in the neighborhood. A fruitless search for that fact has required much time in the investigation. Yet here is a per.on who has had all the time the information sought, but thought it of no consequence. If we could only get together in a proper place the facts known by our members which are not considered of any special importance, what a great help it would be to our investigators. These meetings are the place for such a deposit of facts--a clearing-house in the various fields of research, especially in zoölogy, botany, geology, and anthropology. Since the publication of the papers on Indiana mammals by Prof. Evermann and myself, quite a number of notes which would have been very acceptable a year ago have come into my hands. Many of these were called out by the paper mentioned. From them I select some which may be of interest to the Academy, and possibly to the public generally.

1. *Didelphis virginiana* Shaw. Common Opossum.

I am enabled through the kindness of Mr. W. W. Pfrimmer, to report their occurrence in Jasper and Newton counties. In 1869 when he first knew them there, they were rare, and so continued until 1880. He recalls but two specimens that he had seen in that period. They have been increasing since, and are now tolerably common. Several have been reported the present winter from the vicinity of Lafayette by Messrs. L. A. and C. D. Test. Among them were three young.

Mr. E. J. Chansler, of Knox County, says: 'possums are becoming rare in that locality. About 1859, he notes, as an illustration of the abundance of the animal, one evening, after they had killed hogs, they killed eight opossums in the door-yard before bed time. They had probably been attracted by the offal of the slaughter. In those days, in that land of the persimmon, the edges of the prairies were the places where, in the fall and winter, the two were found together the persimmon and the opossum.

2. *Erethizon dorsatus* (*L.*). Canada porcupine.

Knox County. Formerly found here, but rare. Stafford reports having seen two, the last one about 1834 (Chansler). Mr. Bruce reports seeing one that had been killed in Daviess County in 1837 (Chansler).

3. *Zapus hudsonius* (Zimm.). Jumping mouse.

Newton County (Pfrimmer).

Mahoning County (Ellsworth), O. (E. W. Vickers).

Sandusky, O. (E. W. Vickers).

4. *Geomys bursarius* (Shaw). Pocket gopher.

Newton County (Pfrimmer).

5. *Mus rattus*, (L.) Black rat.

Knox County. At one time numerous, but now extinct. Reported that it was last seen here in 1845 (Chansler).

6. *Mus decumanus*, Pallas. Brown rat; Norway rat.

Knox County. Very numerous; our common rat. Said to have been first seen in 1840 (Chansler).

7. *Castor fiber* (L.). Beaver.

Newton County. Formerly abundant. The remains of their work is yet seen (Pfrimmer).

Bartholomew County. About one mile from the intersection of the Decatur and Jennings County line is a place called the Beaver Pond. There they formerly built their houses (Miss Elizabeth Wright).

Tippecanoe County. Beaver skull taken from Goose Island, Wabash River, in the spring of 1894 by C. A. Schott (Prof. Stanley Coulter).

Knox County. Formerly found. Reported in 1839. Mr. Dubois reports seeing one that had been caught in a trap in 1840. Dams across some of our streams are still visible. Some claim that Montours Pond was caused by Beavers damming Pond Creek (Chansler).

8. *Spermophilus tridecemlineatus* (Mitchill). Striped Gopher.

Newton County. Abundant along hedges and banks. Also in the grassy margins of the fields (Pfrimmer).

Tippecanoe County, 1894. L. A. and C. D. Test.

9. *Spermophilus franklini* (Sabine). Gray Spermophile.

Newton County. Think they are rare. Have seen two. Had one for a pet. They are called "Prairie Squirrels" (Pfrimmer).

10. *Sciurus hudsonicus* (Erxleben). Red Squirrel: Chickaree.

Lake County. Rare.

Newton County. Heard of; not seen (Pfrimmer).

11. *Condylura cristata* (L.). Star-nosed Mole.

Bartholomew County. A specimen described by Miss Elizabeth Wright, appears to be this species. It was taken in their garden near Grammer. In this connection I might quote from a recent letter from Mr. Ernest W. Vickers, of Ellsworth, Mahoning County, O., on the occurrence of this species in that state: "I have found the Star-nosed Mole at Canton, Stark County. One specimen. Another reported, Berea, Cuyahoga County. Common in onion muck. Weymouth, Medina County: Reported. Cuyahoga Falls, Summit County: Specimen found along Cuyahoga River during meeting of Ohio State Academy of Science, in 1892. Portage County: "I took a specimen near Suffield in June, 1894. In this township I collected six specimens in an area of less than four acres in the summer of 1893. This year, 1894, I have found none." (Richland County Geological Survey of Ohio, Zoölogy and Botany, Vol. IV., p. 179, foot-note.

12. *Blarina platyrhinus* (DeKay). Common Shrew.

Although no additional specimens have been reported in this state, I desire to call attention to its occurrence in Ohio. Mr. E. W. Vickers, of Ellsworth, Mahoning County, says: "I found one specimen last year, 1893. This year I collected five of this species on one farm in this township."

13. *Cariacus virginianus* (Bodd). Virginia deer.

Newton County. Extinct. Last deer killed was twenty years ago (1874). One was seen three years ago (1891).

Jasper County. Deer killed about 1890 (Pfrimmer).

Knox County. Found at one time in countless numbers. Now only met with occasionally in the cypress swamps of this county (Chansler).

14. *Cervus canadensis* (Erxleben). Wapiti; elk.

Knox County. Still found here in early part of this century. Mr. Brad. Thompson reports seeing a wild elk in 1830. Mr. Stafford says that he saw an elk that was killed on Pond Creek in 1829 (Chansler).

Daviess County. Mr. Bruce reports seeing elk horns in Daviess County as late as 1850 (Chansler).

15. *Bison bison* (L.). Bison; buffalo.

Knox County. The buffalo in an early day were very numerous. The trail along which they used to travel between the blue grass region of Kentucky and the prairies crossed the Wabash River near Vincennes. George Rogers Clark, writing from Vincennes, mentions the buffalo.

Mr. B. Thompson says his father reported buffalo here in 1808. Mr. A. Stafford tells me of finding buffalo horns on Collins' Prairie (Chansler).

Daviess County. Mr. Bruce reports finding horns that had been dug up by hogs in a marsh in 1840 (Chansler).

16. *Procyon lotor* (L.). Raccoon.

Newton County. Abundant. Have been known to bed up like hogs, two in a bed, on the edge of the marshes. Hunters follow along the marshes, and when the raccoons are found they at once take to the water to escape the dogs (Pfrimmer).

Knox County. Not so common as formerly. The fur traders say they generally get two or three black 'coons each winter (Chansler).

17. *Ursus americanus* (Pallas). Black bear.

Knox County. Moderately common within the memory of a few of our oldest citizens. An old friend told me that when a boy he met with bear quite often. He saw the last one in this county in 1845. The *Vincennes Commercial* in 1882 reported two young black bears having been killed at Montours Swamp that year (Chansler).

Daviess County. Mr. Bruce says the last black bear in this county was killed in 1837 (Chansler).

Newton County. Extinct.

Jasper County. About ten years ago (Pfrimmer).

18. *Lutra hudsonica* (Lacipede.) American otter.

Newton County. Reported within six months. One caught last winter (1893-4). I have seen signs within three years (Pfrimmer).

Lake County. Reported within last few years (Pfrimmer).

Porter County. Reported within last few years (Pfrimmer).

Tippecanoe County. One killed on Goose Island, Wabash River, by C. A. Schott spring of 1894. Skin sold in Lafayette for \$9. The specimen has been seen and identification verified. Mr. Schott reports another slide in the same locality. He says he has seen several other otters. They are extremely shy and difficult to get (Prof. Stanley Coulter).

Knox County. Rare if not extinct. Hunters used to kill them in winter in the snow with clubs as they travelled from one pond to another. Older men remember a familiar slide (Chansler).

19. *Taxidea americana* (Bodd). American badger.

Newton County. Occasionally found.

Benton County. One killed about 1874 (Pfrimmer).

20. *Vulpes vulpes* (L.). Red fox.

Newton County. Along Iroquois River plentiful; elsewhere rare (Pfrimmer.)

Knox County. Common in last fifteen years; before that rare (Chansler).

21. *Urocyon cinereo-argentatus* (Schr). Gray fox.

Knox County. Common to fifteen years ago. Now rare (Chansler).

22. *Canis lupus* (Say). Wolf.

Newton County. One killed two years ago (Pfrimmer).

Knox County. Numerous in the early days. Last one was killed on Birch Run, between Bicknell and Edwardsport by Henry Maclin in 1853. One was killed within one and one-half miles of Vincennes, in Illinois in 1882 (Chansler).

Daviess County. Last seen in 1850, according to Mr. Bruce (Chansler).

23. *Canis latrans* (Say). Coyote, prairie wolf.

Newton County. One killed in November, 1894, along Monon Railroad. Observed in all parts of Newton County within last three years. More numerous in northern portion. A ride of half a dozen miles through the higher marshes will probably reveal two or three. Last year (1893) saw three at one time. They are destructive to poultry, pigs and sheep. This county paid over $100 bounty for wolves killed last year. The rate was $5 for each old one and $2.50 for each young one (Pfrimmer).

Knox County. Not so common as the gray wolf. Found as late as 1854. One authority reports seeing one near Vincennes in 1858. The species has not been authentically reported from the state before (Chansler).

24. *Felis concolor* (L.). American panther.

Knox County. Formerly found. Mr. A. Stafford reports seeing the last one in 1833. Mr. Thompson reports seeing one in 1825. Mr. Bruce reports it in Daviess County as late as 1830 (Chansler).

25. *Lynx rufus* (Guldenstadt). American wild-cat.

Knox County. Rare. One killed near Bicknell in 1832 by Mr. Robert M. Kinsley. Reported about Montours Swamp spring of 1894.

Wells County. One taken near Bluffton early in November, 1894. It weighed 56 pounds (F. M. Noe).

26. *Lepus aquaticus* (Bachman). Water Hare.

Knox County. Mr. Chansler says a brown rabbit has been seen there by different persons. It is said to be much larger than the common gray rabbit. It seems probable that two forms of swamp hares will be found in the lower Wabash valley, the one above noted, which

ranges southwest to the Gulf of Mexico, and the smaller, *Lepus palustris*, Bachman, which ranges to the south and southeast. Careful investigation of the rabbits of southern Indiana is requested.

27. *Corynorhinus macrotis* (LeConte). Big-eared bat.

December 26, 1894, Dr. L. M. Underwood brought to me at the Denison House, Indianapolis, a specimen of this species taken from a cave five miles southwest of Greencastle, Ind., a few days before by Prof. J. P. Naylor. There was another with it, which was not taken. Returning to the cave another time no more could be found. The specimen is now in my collection.

Some Cases of Mimicry in Fishes. By W. J. Moenkhaus.

There are four different species of fish that show a most interesting similarity in their color pattern. They are *Etheostoma blennius*, *Etheostoma uranidea*, *Cottus richardsoni* and *Catostomus nigricans*. They belong to three different families, the first two, darters, to the *Percidæ*; the third, the *miller's thumb*, to the *Cottidæ*, and the last, the black sucker, to the *Catostomidæ*.

The color-pattern consists of four broad transverse bars extending downward and forward. The similarity of this pattern in the darters and the miller's thumb is almost perfect. The black sucker has this pattern only when young. The resemblance here is less perfect.

This remarkable coincidence of color-pattern can be explained on the principle of protective mimicry. The miller's thumb is a very horny, spiny and uninviting fish for food to any enemy that may live on small fish. It may, therefore, have found it advantageous to develop these four prominent bars as a mark to enable its enemy to recognize it and thus make fewer mistakes in capturing undesirable food. The darter and the young sucker on the other hand would be most excellent food for these same enemies. Thus they have found it to their advantage to mimic this miller's thumb and live off its reputation as an undesirable food fish.

This seems all the more probable from the fact that these fish inhabit the same streams.

LEUCISCUS BALTEATUS (RICHARDSON). A STUDY IN VARIATION.* BY CARL H. EIGENMANN.

Nowhere else in North America do we find within a limited region such extensive variations among freshwater fishes as on the Pacific Slope. This is true whether we have reference to the extent of variation between the extremes of the same family or to the limits of variation in any given species.

A comparison of the members of the eight families of fishes having representatives on both the Atlantic and the Pacific slopes, show that, on an average, each of these families has four genera and sixteen species on the Pacific slope, and seven genera and thirty-six species on the Atlantic. Yet, although the number of species is more than twice as great on the Atlantic slope, the variation in the number of fin rays among the Pacific slope species is greater in all but two families. I have recently† made a detailed comparison between the members of the different families, and there attributed this great extent of variation to two causes. First: the fauna is of diverse origin; some of the members are of Asiatic, while others are of Atlantic descent. Second: the fauna is new as compared with the Atlantic slope fauna, and has not yet reached a stage of staple equilibrium. It is possible, as suggested to me by President Jordan, that the Pacific slope fauna has retained its primitive characters more nearly than the Atlantic slope fauna, which shows signs of degeneration in its fins and teeth.

This great variation between the members of the same families is not confined to the fin rays. It is equally true of other characters, but can best be demonstrated in characters whose variation can be numerically expressed. The pharyngeal teeth of the Cyprinidæ offer another striking example of these variations among the Pacific slope species. In a number of cases the variations of the Pacific slope species extend along definite and parallel lines. I have pointed out some of these in the paper quoted above. These lines are directed towards an increase of rays and towards a modification of rays into spines.

The following quotations from Gilbert and Evermann's recent work on the Columbia River basin,‡ illustrate the variation among the different specimens of the same species. "The range of variation seems to be very great, and characters which are of undoubted specific value when applied to Atlantic drainage

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* Contributions from the Zoölogical Laboratory of the Indiana University, No. 11.

† Results of explorations in Western Canada and Northwestern United States. Bull. U. S. Fish Comm. for 1894, pp. 101 to 132, plates 5 to 8. June, 1894.

‡ Report of the Commissioner of Fish and Fisheries on Investigations in the Columbia River Basin in regard to the Salmon Fisheries. Washington, 1894. A Report upon Investigations in the Columbia River Basin with Descriptions of Four New Species of Fishes.

species, do not possess any such value for classification of Pacific coast fishes. Each so-called species seems to be in a very unstable state of equilibrium, and not to have yet assumed or been able to retain, with any degree of permanence, any set of specific characters." "The crosswise series of scales [in Agosia nubila (Girard)] varies from 47 to 70 in number; the barbel [a generic character] is present or absent; the pharyngeal teeth vary from 1, 4–4, 0 to 2, 4–4, 1; and the dorsal fin varies much in position and somewhat in size. These characters occur in various combinations, and with some of these are often correlated peculiarities of physiognomy and general appearance, all of which may serve to put a certain stamp upon the individuals from a single stream, or even from one locality in a stream." These observations, especially those contained in the last sentence, accord exactly with the results obtained by me in another fish and confirm my statement which will be further re-enforced by the present paper, that "each locality has a variety which in the aggregate is different from the variety of every other locality."

The remarkable variation of the Pacific slope species, and more especially the variation in the fin rays, was first noted in preparing my account of the specimens collected in the Columbia and Frazer basins.* This variation was most pronounced in the species of the late genus Richardsonius. Of the species of this genus, I had about 250 specimens, collected in the Frazer and Columbia systems, from tide water to an elevation of 2,786 feet. The later explorations of Gilbert and Evermann have increased this number to 825, and these warrant a re-examination of the points stated by me. For all the date concerning the fin rays of the specimens collected by Gilbert and Evermann, I am indebted to them. Their examination of these specimens was made to test certain conclusions reached by me, and their data, therefore, join mine. In counting the anal rays, I counted the rudiments at the beginning of the fin. These were not counted by Gilbert and Evermann, and to bring their data in perfect accord with mine, it is necessary to add two to the number of anal rays. While the number of rudimentary rays is not always two, it is so often that the exceptions would probably not alter the general results.

At the time I began my studies of these forms, they were regarded as two species, forming a peculiar genus, Richardsonius. They were known to inhabit the Columbia river and the streams about Puget Sound. The compressed belly behind the ventral fins was regarded as the character separating them generically from the related forms. It soon became evident that, while some specimens possessed this, if constant, unquestionable generic character, others did not show

*This variation in the same species does not seem to be confined to the fishes. Professor Ritter, Proc. Cal.; Acad. Sci., 2d ser. Vol. IV., p. 37, finds the same in *Perophora annectens* a new tunicate described by him.

it at all, and the genus was relegated to the limbo of synonymy. The species *balteatus* and *lateralis* were distinguished as follows:

a. Base of anal, 4½ in the length; A. 17 or 18; teeth 2, 5–4, 2. Lower jaw slightly projecting beyond the upper. Coloration plain, the sides bright silvery, crimson in males in spring. Scales 13–62–6. *balteatus.*

aa. Base of anal, 5⅓ in the length; A. 14; teeth 2, 5–5, 2. Jaws equal. Blackish above, a dark lateral band; the interspaces and belly pale; crimson in male in summer. Scales 13–55–6. *lateralis.*

No better distinguishing marks could be wished by any systematist. These characters were found to be so bridged, that the extremes could not be specifically sustained and one of them, probably out of deference to the authority of my friends Jordan and Gilbert, from whom the above diagnosis was modified, was retained as a variety of the other. Now I am inclined to regard *lateralis* as a synonym of *balteatus* with Gilbert and Evermann, but I must take exception to the statement attributed to me that I "considered *lateralis* a subspecies of *balteatus* occupying the same brook with its parent form." I found *balteatus* at the lower Frazer to Kamloops, *lateralis* at the headwaters of the Thomson River down to Kamloops. I see no reason why a subspecies should not occupy the same "brook" with its parent form, for some allied species—between which and subspecies there is, after all, but a mental difference—are, even by Gilbert and Evermann, admitted to live side by side (*Agosia falcata* and *umatilla* at Umatilla).

Leuciscus balteatus ascends the tributaries of the Frazer and Columbia as high as the falls will permit. No other species is found in the Frazer system nor in the Columbia basin proper. The specimens from Brown's Gulch were described as different from those of the lower Columbia, but a comparison of large numbers from other localities has shown them to be but one of the numerous local variations. Three other species, *L. hydrophlox*, *lineatus* and *aliciae* are found in the Snake above the falls. The last two belong to a different section of the genus *Leuciscus* and are not closely related to *balteatus.* All three have probably entered the Snake River from the Utah Basin. As far as known the territories of *L. balteatus* and *hydrophlox* do not overlap, unless those specimens of *balteatus* with only 13 or 14 anal rays are in reality *hydrophlox*, and as far as my experience goes, the number of anal rays is the only ready means of distinguishing the two. *L. balteatus* extends up to or near to the first falls of the Snake, *hydrophlox* is found from this point to the headwaters. A comparison of *hydrophlox*, *balteatus* and *gilli*, the specimens from Brown's Gulch, makes it quite certain that they are all modifications of the same form.

Below are given a number of tables which show the variation in several characters. These tables are all from my own specimens.

TABLE OF VARIATION FOR TWENTY-SIX SPECIMENS FROM MISSION.

Number.	Length in MM.	Dorsal.	Anal.	Scales.	Teeth.*	Depth.	Position of Dorsal.	Sex.	Remarks.
1	140	13	18	12-59-6		[illegible]	(†)	Female.	Keel scarcely evident
2	120	12	21	11-53-5	‡2, 5-4, 1	3[illegible]	(§)	Male.	Median keel scarcely evid't
3	110	13	19	12-60-6	2, 5-4, 2	[illegible]	(§)	Male	Median keel moderate.
4	105	12	20	12-58-6	2, 5-4, 2	[illegible]	( )	Female.	Median keel well developed
5	100	12	19	11-57-6	2, 4-4, 2	[illegible]	(†)	Male	Keel typical.
6	102	12	18	12-60-6	2, 5-4, 2	3[illegible]	(§)	Male.	Keel moderate.
7	91		20	12-57-5	2, 4-3, 1	3[illegible]	( )	Female	Keel evident.
8	92	11	19	12-58-6	2, 5-4, 1	3[illegible]	( )		Keel distinct.
9	95	12	19	12-61-6	2, 5-4, 2	3[illegible]	( )	Male	Keel well developed
10	92	12	21	12-63-6	2, 5-4, 1	3	(§)	Female.	Keel typical.
11	102	12	20	11-62-6	2, 5-4, 2	3[illegible]	(§)	Male	Keel well developed.
12	97	12	20	13-59-6	1, 5-4, 2	3[illegible]	(†)	Male.	Keel moderate.
13	96	12	20	11-59-7	2, 5-4, 1	3[illegible]	(§)	Male	Keel well developed. [fangs
14	93	12	20	12-61-7	2, 5-4, 1	3[illegible]	(†)	Male.	Keel no more than in mos-
15	91	11	19	12-61-6	2, 5-4, 1	3[illegible]	(†)	Male.	Keel distinct.
16	95	12	18	13-59-7	2, 5-4, 2	3[illegible]	( )	Male.	Keel evident
17	90	12	17	13-58-7	2, 5-4, 2	3	(†)	(?)	Keel moderate.
18	80	11	17	11-60-7	2, 5-4, 2	3[illegible]	(†)	Male	Keel typical.
19	77	12	17	57	2, 5-4, 2	3[illegible]	(†)	(?)	Keel well developed.
20	87	12	18	13-61-7	2, 5-4, 2	[illegible]	(§)		Keel well developed.
21	81	12	22	12-58-7	2, 5-4, 2	[illegible]	( )	Female.	Keel moderate.
22	90	13	21	61	2, 5 ?	3[illegible]	( )	Female.	Keel moderate.
23	74	11	16		2, 5-4, 2				Keel moderate.
24	69	13	24	. .	2, 5-4, 2	3[illegible]	(†)		Keel evident.
25	68	13	24	. . .	. .				
26	61	12	23		. .				

* I have frequently observed that the largest individuals among the minnows usually have abnormal numbers of teeth.

† Equidistant from base of middle caudal rays and a point above middle of pupil.

‡ Anterior tooth of main row on left side is large, dagger-shaped, and remote from the others, and points inward.

§ Equidistant from base of middle caudal rays and upper angle of preopercle.

Equidistant from base of middle caudal rays and posterior margin of eye.

TABLE OF VARIATION FOR EIGHT SPECIMENS FROM SICAMOUS.

Number.	Length in MM.	Dorsal.	Anal.	Scales.	Teeth.	Depth.	Position of Dorsal.	Remarks.
1	92	12	19	11-61-6	2, 4-3, 1	4	(?)	
2	92	12	16	11-62-6	2, 5-4, 2		(?)	Keel indistinct.
3	90	12	14	14-62-7	2, 5-4, 2	3[illegible]	(†)	
4	97	12	17	12-60-5	2, 5-4	4		
5	85	12	16	10-62-5	2, 5-5, 3	4[illegible]	(‡)	
6	90	12	18	11-60-6	2, 5-4, 1	4[illegible]	(?)	
7	85	12	16	11-59-5	2, 5-4, 2	4	(†)	
8	77	12	17	11-61	2, 5-4, 1	4[illegible]	(?)	

Equidistant from base of middle caudal rays and upper angle of preopercle.

† Equidistant from base of middle caudal rays and a point above middle of pupil.

' Equidistant from base of middle caudal rays and occiput.

TABLE OF VARIATION FOR EIGHTEEN SPECIMENS FROM THE COLUMBIA AT GOLDEN.

Number.	Length in MM.	Dorsal.	Anal.	Scales.	Teeth.	Depth.	Head.	Position of Dorsal.	Sex.	Remarks.
1	115	12½	15½	12-63-6	2, 5-4, 1	3½		(*)	Female.	Keel nil.
2	104	11½	16½	10-61 ?	2, 5-4, 1			(†)	Female.	Keel evident.
3	103	11½	18½	10-55-5	2, 5-4, 2			(*)	Female.	Keel evident.
4	100	11½	17½	12-59-?	2, 4-5, 2		4?	(*)	Male.	Keel evident.
5	95	12½	15½	56	1, 5-4, 1	4	4½	(‡)	Female	Keel well marked.
6	92	11½	15½			4½	4½		?)	Keel well developed
7	91	12½	17½	57	2, 4 3, 2	3½	4½	(‡)		Keel nil.
8	85	11½	14½				4½	(‡)		Keel well developed
9	85	12.	16½			4½	4?	(‡)		Keel scarcely evident
10	82	11½	16½			4½	4½	(‡)		Keel evident.
11	83	11½	16½			[illegible]		(‡)		
12	77	11	15½			4½		(‡)		Keel evident
13	73	12½	15½			4		(‡)		Keel well developed
14	72	10½	15½			4½		(‡)		Keel moderate.
15	68	11½	16½			4		(‡)		Keel well developed
16	67	12½	17½			3½		(†)		Keel well developed
17	65	12.	15½			4		(§)		Keel strong.
18	62	11.	17½			4½				Keel strong.

* Equidistant from base of middle caudal rays and occiput (beginning of scaled region).
† Dorsal nearer base of middle caudal rays than occiput.
‡ Equidistant from base of middle caudal rays and upper angle of preopercle.
§ Equidistant from base of middle caudal rays and posterior margin of eye.

From these tables it will be noticed that the number of dorsal rays is quite constant, being from 10 to 13. The variation in the anal is enormous, but this I shall treat in detail. The scales are seen to vary from 10 to 14 above the lateral line; from 55 to 63 along the lateral line, and from 5 to 7 below the lateral line. There is nothing unusual in these variations, they are surpassed or equalled by other members of the same family. The variation in the teeth is great. With one exception, there are two teeth in the lesser row of the left side. The major row on the left side contains 4 or 5 teeth in the proportion of 1 to 6. In the right side 3, 4 and 5 teeth were found in 4, 30 and 2 specimens respectively. In the lesser row of the right side 13 specimens had one tooth, 20 had 2 teeth and 1 had 3. This last specimen with dental formula 2, 5-5, 3, exceeds, the dental formula of all the 175 Atlantic slope species of this family. Among these dental formulæ we find variations, the extremes of which have been taken as generic characters. The different combinations of teeth and the number of specimens having each number are as follows: One with 1, 5-4, 1; one with 1, 5-4, 2; two with 2, 4-3, 1; one with 2, 4-3, 2; one with 2, 4-4, 2; one with 2, 4-5, 2; one with 2, 5-3, 2; eleven with 2, 5-4, 1; sixteen with 2, 5-4, 2; one with 2, 5-5, 3. The usual or nominal formula is 2, 5-4, 1 or 2. The variation through ten different combinations is exceptional.

The proportions, while varying considerably, do not show any wider fluctuations than usual. The position of the dorsal, on the other hand, varies from midway from base of the middle caudal rays, and from a point behind to a point above the middle of the eye.

In the development of the keel behind the ventral fins we find again a great fluctuation in specimens from the same locality. In some, the keel is very sharp; in others it is entirely absent, and between these forms, we have all shades of variation. If uniform, it would be of generic value.

Now, as to the variation of the anal rays. The lowest number recorded is 13 (after adding 2 to Gilbert and Evermann's lowest number), and the highest is 24. This gives a total variation of 12 rays. This would be a large variation for any fish, but becomes phenomenal when it is considered that the variation in the number of anal rays of the 175 Atlantic slope species extends only from 6 to 14, a total variation of but 9 for 175 species as compared with the variation of 12 for a single species. The high number of rays reached is also phenomenal, for, leaving out of consideration the two rudimentary spines, the highest number of anal rays, 22, is ten more than the number found in any other Pacific Cyprinoid, and eight more than the number found in any Atlantic species. The average number of rays is seventeen. The variation to lower numbers extends through 4 rays to 13. The variation to higher numbers is much greater, extending through 7 rays to 24. Not only is the extent of variation greater towards higher numbers, but the number of specimens varying in that direction is much greater. Of 825 specimens but 22.3 per cent. have the average number of rays. This is the largest per cent. for any given number of rays. Thirty-four per cent. of all the specimens have fewer than the average number of rays, while 42.9 per cent. have more than the average number. A more striking illustration of determinate variation could not be wished.

Figure 1 graphically represents the variation of the species as shown by the 825 specimens examined. The total hight of the vertical lines represents the greatest possible number, 100 per cent., that could have the given number of anal rays indicated at the bottom of the lines. The curve shows the actual per cent. of specimens having each particular number of rays. Were the variation promiscuous the curve would be symmetrical. The symmetry shows the inherent tendency to a higher number of rays in this fish. It may be well to bear in mind that no other species has a higher number of rays—that no other species joins this curve on the right—while at least one, probably two, related species living in the head-waters of the Snake River have fewer rays, *i. e.*, joins this curve on the left. The curve of *Leuciscus hydrophlox* will not only join this curve, but overlap

it, showing that in the number of anal rays *L. balteatus* and *L. hydrophlox* intergrade.

To facilitate the study of the local variations I give below all the data concerning the 825 specimens of this fish. The first column gives the name of the stream and locality; the second column gives the elevation of the locality; the third, the number of specimens collected at the given place; the fourth, the extent of variation in the anal rays in the specimens from the locality, and the succeeding columns, the number of specimens having the particular number of anal rays indicated at the head of the columns. The figures below the column representing the average number of rays for the specimens of the locality are in italics.

DETAILS OF THE VARIATIONS IN THE ANAL RAYS.

Locality.	Elevation.	Number of Specimens.	Variation.	Number of Anal Rays. 13	14	15	16	17	18	19	20	21	22	23	24
Payette River, Payette	2,150	154	9			3	25	29	*27*	28	25	12	3	2	
Boise River, Caldwell	2,372	99	0				11	17	*29*	19	10	5	3		
Frazer River, Mission	1	79	0				2	7	13	*23*	18	8	2	2	2
Little Spokane River, Dart's Mill	1,850	70	5		14	*30*	19	6							
Small Creek, at Sand P't, Idaho	2,100	67	6			2	19	*36*	3	6					
Shuswap Lake, Sicamous	1,300	58	6			3	13	*28*	8	5					
Lake Washington, Seattle	1	47	7			16		13	4	1					
Umatilla River, Pendleton	1,070	26	5		1	5	*10*	9	1						
Grand Ronde, La Grand	2,786	23	4		2	6		4							
Umatilla River, Umatilla	300	22	6					2	6	*5*		6	1		
Colville River, Meyers' Falls	1,[illegible]00	21				1	*5*	6	2			1			
Columbia River, Golden, B. C.	2,550	18	5		1	7	*5*	4	1						
Clear Water River, Lewiston	750	16							3	5		4			
Griffin Lake	1,980	14	4		3	7	3	1							
Brown Gulch, Silver Bow	5,344	14				2	*10*	1	1						
Skookumchuck River, Chehalis	204	13	6			2		1	7	*2*					
Spokane River, Spokane	1,910	11	5		1	1	5	1	3						
Hangman Creek, Spokane	1,910	11	4			2	2	[illegible]	2						
Flathead Lak	3,100	11	4			1	1	*6*	3						
Snake River, Payette	2,150	10	5						1	1		3	1		
Natchess River, North Yakima	1,078	8	5		1		3	*1*	3						
Pend d'Oreille River, Newport	2,000	8	3				[illegible]	1	2						
Walla Walla River, Wallula	326	6	4						2	*2*		2			
Post Creek, Flat Head Lake	3,100	6	3					*4*	1	1					
Potlatch Creek, Lewiston	1,200	4	3						1	*1*					
Newaukum River, Chehalis	204	3	2					*2*	1						
Columbia River, Pasco	375	3	3							1	*1*	1			
Thompson River	1,158	4	3					1	1		1		1		
Columbia River, Revelstoke	1,475	1	1			*1*									

After a detailed examination of the specimens collected by myself I found that every locality has a variety peculiar to itself. The number of localities has been trebled by the explorations of Gilbert and Evermann, and the number of specimens raised from 250 to 825, and their detailed examination of these specimens bears out the above statement for every locality examined by them. Unfortunately they allowed themselves to be side-tracked by minor issues, and did not mention this fact of local variation except in connection with another species.

I collected at three localities in the Fraser basin. At Mission, B. C., I obtained seventy-nine specimens in water which is affected by the high tides. At Sicamous, at an elevation of 1,300 feet, I collected fifty-eight specimens. In Griffin Lake, at an elevation of 1,900 feet, I secured fourteen specimens. Four others were secured at Kamloops, but these are too few to aid us in our study.

The variation for these localities is represented by the three curves of figure two. The vertical lines stand for fin rays to total height of the figure for 100%. The various heights of these curves represent the per cent. of specimens having the given number of rays. The variation is seen to be much the greatest at Mission, a fact which is largely to be attributed to the greater number of specimens secured at this place. The variation from the normal, which is nineteen rays, to a higher number of rays, is as great as the entire variation for the next locality. At Sicamous a much larger per cent. has the normal number of rays, but the normal number has been decreased to seventeen The curve for Griffin Lake is interesting, because the normal number of rays has again been decreased by two. In other words, the higher the altitude the fewer the number of rays and the narrower the limit of variation.* Moreover, the curves are not symmetrical for any of the three localities, but in the aggregate the more gradual slope is on the side of an increase in the number of rays, a condition which, considering the general variation of rays on the Pacific Slope, seems to indicate that the number of rays of this species in the Frazer system is increasing, and that the increase is progressing from lower to higher altitudes.

A glance at the remaining curves will be sufficient to show that no two curves are alike, that the per cent. of specimens having a given number of rays differs with each locality. Naturally the curves constructed from a large number of specimens represent the true conditions better than the curves constructed from

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In their recent paper Gilbert and Evermann have raised this specific statement, which occurs in my paper quoted above, into the dignity of a "theory" and "generalization," which it was never intended to be, and their arguments against it as a "theory" and "generalization" are, therefore, not appropriate.

but a few. The extent of the variation varies largely with the number of specimens examined; that is, the probability of securing extremes becomes greater with an increase in the number of specimens collected.

The greatest extent of variation for any locality as far as known is through nine rays. This has been found only when over seventy specimens have been compared. It decreases to about five rays with ten specimens. The total variation for the species has not been found at any one place.

The question of variation with elevation is an interesting one, and may be taken up in some detail.

In the following table *all* the localities are grouped according to their average number of rays:

Average Number of Rays.	Number of Localities.	Localities, With Their Elevations.
15	3	Little Spokane River, 1,850; Griffin Lake, 1,990; Revelstoke on the Columbia, 1,475.
16	8	Lake Washington, 1; Umatilla River, Pendleton, 1,070; Spokane River, 1,910; Colville River, Meyers Falls, 1,200; Columbia River, Golden, 2,550; Grande Ronde River, La Grande, 2,786; Silver Bow, Brown's Gulch, 5,344; Pend d'Oreille River, Newport, 2,000.
17	7	Newaucum River, Chehalis, 204; Natchess River, North Yakima, 1,078; Sicamous, 1,300; Hangman Creek, Spokane, 1,910; Small Creek, 2,100; Post Creek, 3,100; Flat Head Lake, 3,100.
18	3	Payette River, 2,150; Boise River, Caldwell, 2,372; Skookumchuck River, Chehalis, 204.
19	5	Mission, 1; Umatilla, 300; Walla Walla River, 326; Potlatch Creek, 1,200; Kamloops, 1,158.
20	3	Clear Water Lewiston, 750; Snake River, Payette, 2,150; Columbia River, Pasco, 375.

The lowest average, 15, is found in but three localities, the lowest of which is at an elevation of 1,475 feet. This last is of no value since only one specimen was obtained, and the chances are against an average specimen if only one is taken.

The second average is found all the way from tide water to an elevation of 5,344 feet. It is, however, notable that only one of the localities, Lake Washington, which does not belong to one of the two large water systems, is at a low elevation. The lowest of the other seven, all of which belong to the Columbian system, is at an elevation of 1,070 feet.

The third average, which is also the general average for all the specimens, is found in seven localities, the lowest of which is at an elevation of 204, the highest at 3,100. All but the first, which, again, does not belong to one of the large river systems, are at an elevation above 1,000 feet.

The fourth average ranges from 204 to 2,372 feet.

The fifth average, 19 rays, is found in five localities, three of which are below 1,000 feet, and the highest is at 1,200.

The sixth average, of 20 rays, varies from 375 to 2,150 feet; two of them are at an elevation of less than 1,000 feet.

This grouping does not show any uniform variation with the altitude. It may be emphasized that the lowest average is not found below 1,475 feet, that only one of the seven having an average of 16 rays is found below 1,000 feet, and that but one of the eight having an average of 17 rays is found below 1,000 feet. From the last but three specimens are known. It may be further emphasized that three of the five localities having an average of 19 rays are found below 1,000 feet, and that two of the three having an average of 20 rays are found below 1,000 feet. Generally the lower locality has the larger number of rays, to which there are several notable exceptions, Lake Washington and Snake River at Payette. These facts can be presented in curves for groups of localities.

Taking the specimens from the different groups of localities we obtain the following:

Elevation, Feet.	Number of Localities.	Number of Specimens.	Extent of Variation.	General Average of Anal Rays.
1 to 750	8	189	11	18.4
1,078 to 2,000	12	234	10	16.6
2,001 to 3,100	8	388	10	17.5
5,000 to ——	1	10	.....	16

Whether we consider the number of localities having a high average of rays or whether we consider the averages of all the specimens from a similar horizon, we find that the largest number of rays is found in the lower horizon. Furthermore, the extent of variation for the 189 specimens from 1 to 750 feet is greater than the variation for 234 and 588 specimens of the higher horizons. The variation for these three horizons is given in the three curves of figure 3.

In the above we have considered the localities regardless of the system to which they belong. Lake Washington and the Newaucum and Skookumchuck rivers belong to separate short water courses. Eliminating these and considering the localities of the Frazer and of the Columbia systems separately we get the conditions described for the Frazer system above and for the Columbia system the following—arranging the localities in the order of elevation:

Locality.	Elevation.	Av. No. of Anal Ray.	Locality.	Elevation.	Av. No. of Anal Ray.
Umatilla	300	19	Hangman Creek	1,910	17
Wallula	325	19	Pend d'Oreille	2,000	16
Pasco	375	20	Small Creek	2,100	17
Lewiston	750	20	Payette	2,150	18
Pendleton	1,070	16	Snake River	2,150	20
Yakima	1,078	17	Caldwell	2,372	18
Colville	1,200	16	Golden	2,550	16
Potlatch	1,200	19	La Grande	2,550	16
Revelstoke	1,475	*15	Flat Head	3,100	17
Little Spokane	1,850	15	Brown's Gulch	5,344	16
Spokane	1,910	16			

*Only one specimen.

Summarizing this: Below 1,000 feet the averages are 19 and 20; above 1,000 feet only one averages 20, only one reaches 19, two reach 18, four have 17, seven have 16 and two have 15. These figures "are not so unanimous in their indications" of a decrease of rays with an increase of altitude as those for the Frazer system. But the lower locality generally possesses a higher number of rays. Here, where we have data from many widely separated branches, a close variation of rays with altitude is not found. Local issues have modified national tendencies among these fishes in the Columbia system.

Among the locality curves (figures 4 and following) the ideal curve is most nearly approached at Caldwell. The variation from the average is here equally great in both directions, and the curve of the ascending variation is almost identical with the curve of the descending variation. Nearly as ideal conditions are found at Little Spokane, where the extent of variation is much smaller. *A priori* such symmetry or approach to symmetry is to be expected for each locality, but the deviations from it are many and great. The many shoulders and peaks in localities from which but few specimens have been collected, indicate probably nothing so much as the lack of a sufficient number of specimens. When but ten specimens are examined, each specimen, more or less, makes such a vast difference in the character of the curve that the localities with less than twenty specimens may be dismissed without further notice.

Aside from curves, such as that of Little Spokane, where a certain number of rays is the predominant one, we have curves, such as that of the Payette River, where the number of specimens having 16, 17, 18, 19 and 20 rays, is nearly equal. Still another type of curve is represented by the curves for Lake Washington, Colville and Umatilla, in which two numbers predominate, with the intervening numbers in minority. The conditions are most marked at Umatilla, where we have two incipient varieties with 18 and 21 as the predominatin number of rays.

I have given at the outset the probable causes which have brought about the great differences between the Pacific slope fishes.

We must look to other causes for the great variation between species of undoubted Atlantic origin and especially the variation in the same species, which reaches its culmination in *Leuciscus balteatus* and *Agosia nubila*. The climatic, altitudinal and geological differences in the different streams and even in the length of the same stream are very great on the Pacific slope. To these different environments we must attribute the conditions set forth in the present paper for *Leuciscus balteatus*. These differences in different localities in the same stream can only become established in non-migratory species. No such differences are to be expected for a migratory species. Isolation for the specimens of any locality when free intermigration is possible, seems strange. An analogous condition is to be found on the Galapagoes Islands. Dr. Baur tells me that islands within plain sight of each other harbor distinct varieties of the same species of birds which could readily intermigrate, but do not.

This raises the question of the sort of influence exerted by the environment. Is it merely selective, or is it directive? Is the variation promiscuous and inherent in the species, or is it determinate and forced in certain directions by the environments? The latter seems to me the better way of reading such conditions as are represented by the many curves which show a greater variation towards an increased number of rays than towards a decrease of rays. Here the variation is not promiscuous, but definitely determinate. See, in this connection, the curve for all the specimens.

The origin of new varieties is admirably illustrated by the curves for Lake Washington and Umatilla. In these, two distinct peaks are found. While no varietal value is claimed for these peaks, isolation of members of such peaks, either physiologically or locally, would tend to establish such incipient varieties as species.

EXPLANATION OF FIGURES.

The vertical lines in all cases stand for a definite number of anal rays. The total height of the figures represents 100 per cent., and the height of the curves at any point, the per cent. of specimens having the particular number of rays in the anal.

Fig. 1. Curve of variation for 217 specimens of *Leuciscus hydrophlox* from the upper Snake, and 825 specimens of *Leuciscus balteatus* from many localities, ranging from 1 to over 5,000 feet. The two series of specimens are combined in the broken line curve.

Fig. 2. Three curves showing the variation of the three localities represented from the Frazer system:

Griffin Lake, 1,900 feet, 17 specimens.

Sicamous, 1,300 feet, 58 specimens.

Mission, 1 foot, 79, specimens.

Fig. 3. Three curves showing the variation:

a, of 234 specimens from 1,000 to 2,000 feet elevation;

b, (broken line) 388 specimens from 2,000 to 3,000 feet elevation;

c, 189 specimens from 1 to 1,000 feet elevation.

Fig. 4. Variation of 99 specimens from Caldwell, 2,372 feet.
Fig. 5. Variation of 23 specimens from La Grande, 2,786 feet.
Fig. 6. Variation of 70 specimens from Little Spokane, 1,850 feet.
Fig. 7. Variation of 79 specimens from Mission, 1 foot.
Fig. 8. Variation of 154 specimens from Payette River, 2,150 feet.
Fig. 9. Variation of 26 specimens from Pendleton, 1,070 feet.
Fig. 10. Variation of 16 specimens from Clear Water, 750 feet.
Fig. 11. Variation of 14 specimens from Brown's Gulch, 5,344 feet.
Fig. 12. Variation of 67 specimens from Small Creek, 2,100 feet.
Fig. 13. Variation of 47 specimens from Lake Washington, 1 foot.
Fig. 14. Variation of 22 specimens from Umatilla, 300 feet.
Fig. 15. Variation of 21 specimens from Colville, 1,200 feet.
Fig. 16. Variation of 18 specimens from Golden, 2,550 feet.
Fig. 17. Variation of 13 specimens from Skookumchuck, 204 feet.
Fig. 18. Variation of 11 specimens from Hangman's Creek, 1,900 feet.
Fig. 19. Variation of 12 specimens from Flat Head Lake, 3,100 feet.
Fig. 20. *Leuciscus balteatus* from Mission, the specimen now in the British Museum.
Fig. 21. *Leuciscus gilli*, from Brown's Gulch.
Fig. 22. *Leuciscus hydrophlox.*

The last two cuts are reproduced by permission of Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries.

THE RED-FISH OF THE IDAHO LAKES. BY B. W. EVERMANN AND J. T. SCOVELL.

Observations Upon Some Oklahoma Plants. By E. W. Olive.

The botany of Oklahoma is exceedingly interesting, because this territory is a borderland region between the Gray's Manual and Western Texas Manual regions. Until about five years ago the plants of this district were but little known to botanists, and the results of recent collections disclose a flora rich in interesting forms. Especially valuable is a "List of Plants Collected by C. S. Sheldon and M. A. Carleton in the Indian Territory in 1891," published as contributions from the National Herbarium in 1892.

The months of July and August, 1893, were spent in and about Payne County, in the very northeast of Oklahoma, about ninety miles south of the Kansas line through the Cherokee strip and about 150 miles west of Arkansas. This is in latitude about 97° west, and is but a few miles south of the parallel bounding on the north Tennessee and North Carolina, so that the collections were made just south of the line of the extreme southwestern limit of Gray's Man., 6th ed. About 175 species of Phanerogams and Pteridophytes were collected, about sixty of them being new to Messrs. Sheldon and Carleton's lists, most of these, however, the commoner plants, and thirteen of which are not reported in Gray's Manual. Of this thirteen four are not included in Dr. Coulter's Manual of the Texas Flora, nor nine of them in his Botany of the Rocky Mountain Region; but only *one* of the thirteen fails to be reported in *all* of these manuals of the surrounding regions. This is *Oenothera trifida*, L., determined by Prof. John M. Coulter and pronounced by him "probably *var. integrifolia*, Torr. and Gr., although the species and variety show various stages of intergradation." This plant was somewhat abundant in cultivated fields near Cimarron City.

These thirteen plants are *Talinum calycinum*, Engelm., found abundantly on the red sandstone rocks outcropping in ravines and along the Cimarron River; *Galactia mollis*, Michx., in dry sand along the river banks; *Acacia filicina*, Willd., abundant in the sandy woods; *Oenothera trifida*, L., var. *integrifolia*, Torr. and Gray; *Gaura villosa*, Torr., showing gradations into "forms;" *Sesuvium Portulacastrum*, L., in sand along the saline banks of the river; *Cynosciadium pinnatum*, D. C., but one plant collected along a roadside; *Aster patens*, Ait., var. *gracilis*, Hooker, the variety not in Gray's Manual, very abundant in rich, sandy grounds near the river; *Baccharis glutinosa*, Pers., the fertile plant conspicuous by its very long and white pappus along the sandy river banks; *Eriogonum longifolium*, Nutt., on dry prairies; *Cooperia Drummondii*, Hook., near Stillwater on rich prairies; *Desmanthus Jamesii*, T. and G., very abundant on dry prairies; *Aphanostephus ramosissimus*, ? D. C. (Professor Coulter thinks this is probably this species, though

the fruit is immature), found in abundance in sand and in the river bottoms; and *Marsilia vestita*, Hook. and Grev., in and along the mucky banks of a pond near Perkins. This marsilia was two to three inches larger than the type.

Probably all of these thirteen plants ought to be included in Gray's Manual, because of the great similarity of the flora of this region to that of southern Kansas. The climatic and geologic conditions are furthermore so very similar in both regions, and this, combined with the fact of the proximity of the Cimarron and Arkansas rivers, flowing southward through the Territory from Kansas, would tend to make the floras very alike.

If it is true, as has been said, that the Indian word *Oklahoma* means the "home of the red earth," then it is a very appropriate name, since the first thing that strikes the traveler's eye is this redness of the soil. A large part of northeastern Oklahoma is distinguished by out-cropping "red beds," which also extend northward into several counties of Southern Kansas, while salt marshes and gypsum hills are associated with the red beds in both regions. Much of the uplands is thus distinguished, while the lowlands are very sandy, some of the fertile river bottoms, however, bearing a rich and diversified flora.

Many of the plants collected show strikingly the transition from the eastern to the western plains flora. Many show also the special characters peculiar to the plants of sandy regions. They have to contend generally with an adverse environment—a dry, sandy or gravelly soil—from which the water is rapidly drained away.

Rainfall in this extreme eastern district of Oklahoma is extremely local. For example, during the summer of 1893; the crops along the river bottoms and in limited spots on the uplands thrived under the influence of the local rains, while but a few miles to the west, about Guthrie, the corn crops were much injured by the drought. The flora seems to reflect such local characteristics. The drier districts present singularly dwarfed forms and show the gradual assumption of protective characters. The plants are "protected against too rapid transpiration by thickened leaves and epidermis, sunken stomata, absence or narrowness of leaves, or an unusual amount of wooliness or hairiness."

There is excellent timber in some portions of this eastern part, but the trees look dwarfed compared with our Indiana trees. There is quite a number of the common oaks—Spanish oak, post oak, but most abundant in the upland reduced forests is *Quercus nigra*, L., the dwarfed, gnarled "black jack." There are some hickories, black walnuts, tall cotton-woods and elms along the river and creeks, the elms bearing abundantly large bunches of mistletoe.

A few observations as to the occurrence and habitat of a few plants may be interesting. In the rich sandy land along the river bottoms the commonest shrubs are the button-bush, or *Cepalanthus occidentalis*, L., *Stillingia sylvatica*, L., *Rhus copallina*, L., and others. On *Stillingia* was found an *Æcidium* which has not been reported on this host, as far as can be determined. Somewhat abundant in similar places were *Argemone platyceras*, Link and Otto, *Callirhöe involucrata*, Gray, *Dalea laxiflora*, Pursh., *Frœlichia floridana*, Moq., *Indigofera leptosepala*, Nutt., and *Aphanostephus ramosissimus*, D. C. In wet and salty sand near the river, were *Pluchea camphorata*, D. C., *Sesuvium portulacastrum*, L., and in dry sand, *Cycloloma platyphyllum*, Moq., *Baccharis glutinosa*, Pers., and *Dalea lanata*, Spreng. The latter is reported in Gray's Man., to have "3–4 pairs" of leaflets, while 6–7 pairs were more usual on the specimens collected. On the high bluffs of the river *Yucca angustifolia*, Pursh., was occasionally met with.

In the woods which extend back from the river bottoms two or three miles are *Cassia Chamæcrista*, R., and *C. nictitans*, L., or "sensitive plant," flowering especially abundantly during July and August; *Clitoria mariana*, L., *Gaura villosa*, Torr., *Œnothera biennis*, L., var. *grandiflora*, Lindl., a beautiful passion flower, *Passiflora incarnata*, L., *Liatris squarrosa*, Willd., *Chrysopsis villosa*, Nutt, in many of its variable forms, *Asclepias verticillata*, L., and *A. stenophylla*, Gray, and low shrubs of buckthorn, *Bumelia lanuginosa*, Pers. One perhaps noteworthy point was the occurrence of *Ludwigia alternifolia* in sandy but perfectly *dry* ravines. Gray's manual reports the habitat of this as "swamps."

The whole prairie region is characterized by an abundance of plants belonging to the orders *Leguminosæ* and *Compositæ*. Particularly abundant on the prairies are *Petalostemon multiflorus*, Nutt., *P. violaceus*, Mx., *Amorpha canescens*, Nutt., *Desmanthus Jamesii*, T. and G., *Dalea aurea*, Nutt., *Solidago Missouriensis*, Nutt., *Helianthus mollis*, Lam., *Hieracium longipilum*, Torr. The fact is significant that of the 175 species collected, 33 were *Leguminosæ* and 32 were *Compositæ*. *Sabbatia angularis*, Pursh., *S. campestris*, Nutt., and *Buchnera Americana*, L., give a great deal of color to the prairies during June and July. *Linum sulcatum*, Riddell, *Ceanothus Americanus*, L., *Jatropha stimulosa*, Michx., *Euphorbia corollata*, L., *E. petaloidea*, Eng., *E. marginata*, Pursh., occur on the richer prairies, while *Œnothera Missouriensis*, Sims., *Houstonia angustifolia*, Mx., *Stenosiphon virgatus*, Spach., *Opuntia Missouriensis*, D. C., and *Gerardia densiflora*, Benth., are found on dry, sterile prairies. A very severe case of poisoning was incurred from collecting *Euphorbia corollata*, L. This, I believe, has been mentioned in the Botanical Gazette as one of our poisonous plants.

A very paradise for a collector of aquatic vegetation is a large shallow pond near Perkins, Oklahoma. Several *Sagittarias*, *Nelumbo lutea*, Pers., *Potamogeton fluitans*, Roth., the latter growing "rarely in ponds" (Gray's Man.), *P. hybridus*, Michx., are most abundant throughout, while near the edges *Heteranthera limosa*, Vahl., *Ludwigia cylindrica*, Ell., *Herpestis rotundifolia*, Pursh, and *Marsilia vestita*, Hook. and Grev., grow rife.

As before suggested, the special interest of this region lies in the fact of the meeting of two floras and the sometimes abrupt but generally gradual transition of one into the other. The flora can not be studied comprehensively except by an extended period of field work and carefully noting all the environmental conditions. The farther west one goes into the territory, the more sandy and desert the regions become, and such are the variations from some of the more eastern forms, no doubt the result of a change in habitat, that many are classed as varieties. According to Mr. Coville's suggestions in his "Botany of Death Valley Expedition," the shrubs and trees and, on the prairies, the *perennials*, should especially be noted to determine characteristic plants of the flora.

Grateful acknowledgments are due to Dr. John M. Coulter and Prof. E. B. Uline for kindly determining some of the species and checking most of the list of collections.

REDISCOVERY OF HOY'S WHITE FISH, OR MOON EYE. BY BARTON W. EVERMANN.

SAXIFRAGACEÆ IN INDIANA. BY STANLEY COULTER.

Represented in Indiana by nine genera, as follows: *Saxifraga* L., *Sullivantia* Torr. and Gray, *Tiarella* L., *Mitella* Tourn., *Heuchera* L., *Parnassia* Tourn., *Hydrangea* Gronov., *Philadelphus* L. and *Ribes* L.

The representatives of *Philadelphus* are evident escapes, and their inclusion in former lists is doubtless due to the youthful ebullience of the collectors. Both *P. inodorus* L. and *P. grandiflorus* L. are eastern and southern forms, the former ranging along the mountains from Virginia to Georgia and Alabama, the other along streams from Virginia to Florida. Both are of easy cultivation and escape readily in favorable localities, but so far as I have record have failed to maintain themselves. Until further evidence the genus and included forms should be excluded from state catalogue.

Saxifraga is certainly represented in the state by *S. Pennsylvanica* L., which has a fair distribution in the central and northern portions of the state, and which

is represented by numerous herbarium specimens from this region. Possibly *S. Virginiensis* Michx. may be added to the list, being reported from Dearborn County by Dr. S. H. Collins, but of which I have seen no specimen. The range does not make it impossible that it is found in the State, although certainly rendering the determination doubtful. The plant is "northward" in its abundant range, though found in Tennessee on the authority of Dr. Gattinger.

Sullivantia Ohionis Torr. and Gray has a definite locality of extremely narrow limits on a limestone cliff at Clifty Falls, Jefferson County. From this point all herbarium specimens have come. It is reported by Dr. C. R. Barnes, from near Washington, and by Baird and Taylor, from Clark County. It is, however, certain that the plant does not occur in any abundance, except in the Clifty Falls station. From my own experience in attempting to extend the range of Sullivantia, I am inclined to believe that the localities added by Professor Barnes and Messrs. Baird and Taylor were from an incorrect reference of immature forms. The plant is remarkable for its occurrence in widely separate stations. Although the manual range seems broad, an examination of the local lists shows that *Sullivantia Ohionis* is entitled to rank as a *rare* plant.

Tiarella cordifolia L. is reported by Dr. Phinney in his list, which embraces the counties of Jay, Delaware, Wayne and Randolph. I have seen no Indiana specimens of this form. The sixth edition of the manual includes Indiana in the range, which reads, "*Rich, rocky woods, New England to Minnesota and Indiana and southward in the mountains.*" Whether the inclusion of the form is based upon Dr. Phinney's report or not, I am unable to state. The habit of the plant would lead to its occurrence, perhaps, in this particular region, if it extends so far southward. Dr. Phinney reports it as "common" in rich woods. The state catalogue gives the plant, referring it to St. Joseph County, but not giving authority for its inclusion. The form is one of great interest, and efforts should be made in the direction of its rediscovery.

Mitella diphylla L. is fairly well distributed, being especially abundant in the central and eastern counties. It is definitely reported from the following counties Jefferson and Clark in the south, Noble in the north, Putnam in the central, and Jay, Delaware, Randolph and Wayne in the east. It also occurs in relative abundance in Tippecanoe. It is not, however, reported from the southeastern, southwestern or western counties. Its mass distribution is evidently in the central and eastern regions of the State.

Heuchera is represented by three species, *villosa*, *Americana* and *hispida*.

H. villosa Michx. is reported only from Clark County. It was first collected by Dr. C. R. Barnes, whose determination of the form is verified by specimens in

the Purdue herbarium. It was afterward reported from the same region by Baird and Taylor, who seem to have made no specimens. No notes are at hand concerning the abundance of the form in this single station and nothing concerning the local conditions. The extension of the range of this species from "Rocks, Md., to Kentucky and southward, in and near mountains" of the Fifth Edition of Manual, to "Rocks, Md., to Georgia, west to Indiana and Missouri," of the Sixth Edition, is doubtless, so far as Indiana goes, based upon this collection of Dr. Barnes.

The extreme paucity of notes accompanying, serve to emphasize certain features of the paper, which I had the honor to present to the Academy last year. Beyond the mere fact of the "Station" which might mean any point in an entire county, nothing definite is known concerning this plant, which is *rare* at least in the state.

H. Americana L., is much more abundant and more generally distributed than either *H. villosa* or *H. hispida*, indeed with perhaps the exception of *Ribes* and *Hydrangea* the most marked member of the family in the state. It is definitely reported from twelve (12) counties and is probably found in all parts of the state.

H. hispida Pursh has been collected from Vigo County by W. S. Blatchley and his determination is verified by a specimen in the DePauw herbarium. I have made no critical study of the form and am not able to pass upon the accuracy of the reference. The range of this species is somewhat strange. Its home seems to be in the mountains of Virginia, it is also reported from Illinois by Dr. Mead, from which point its range is northwestward. We now seem to have an intervening station in Indiana, somewhat the more remarkable as occurring in the lowlands of the state.

Parnassia Caroliniana Michx. occurs in the northern part of the state, being reported from Noble County by Van Gorder and Kosciusko by W. S. Blatchley, the latter collection being in the DePauw herbarium. The region reported is the one in which the form would be expected in our state. Its range would probably be found to cover most of our northern counties, if investigations were made during July–September.

Hydrangea arborescens L., as far as our present knowledge goes, seems to be fairly abundant from northern central counties, southward. It is not, however, reported from the northern tier of counties, although it may occur in favorable localities.

Ribes is our most important genus, not only in number of species, but also in individual representatives. Six species are reported as occurring within our limits.

R. cynosbati L. is our most common form and, probably, is to be found throughout the state, with the exception, perhaps, of the extreme southwestern counties.

R. gracile Michx. is reported definitely only from Vigo County, by W. S. Blatchley, his plant being found in DePauw herbarium. It is probable that some forms reported as *R. rotundifolium* Michx., by earlier collectors, may be referred to this form.

R. rotundifolium Michx. is reported from Jefferson County (J. M. C.) and Clark County (B. and T.) No herbarium specimens of these collections are available. It is probable, however, that this species does not occur within the state and that the forms should be referred to *R. gracile*, *rotundifolium* being an eastern and mountainous form extending from western Massachusetts and New York south to North Carolina, following generally the Allegheny range. It is probable that *R. rotundifolium* will have to be excluded from the state list.

R. oxyacanthoides L. is reported fom Noble (Van G.), Jefferson (J. M. C.) and Clark (B. and T.). Though no herbarium specimens have yet been seen, the form doubtless occurs in the state. Specific reports as to its occurrence, with confirmatory specimens, if possible, are greatly to be desired.

R. floridum L'Her is reported from Noble to Jefferson, through the eastern counties of the State; it is not reported from western or southwestern counties. While no herbarium specimens have yet come to my notice, it is doubtless a member of our state flora. The latest stations are Montgomery County, near a swamp (single station E. W. Olive), Madison County (Walker).

R. rubrum L. var. *subglandulosum* Maxim. is reported from Clark County (B. and T.), and Jefferson (J. M. C.). No herbarium specimens have been examined. The manual range includes Indiana specifically, an addition in 6th ed., probably based upon this citation.

It is remarkable that of the sixteen species representing this family in Indiana (excluding two species of Philadelphus) *seven* are of extreme interest, either because of their rarity or because of their extending previous ranges.

They are:

Saxifraga Virginiensis, Michx. [Not authenticated.]
Sullivantia Ohionis, Torr. and Gray.
Tiarella cordifolia, L.
Heuchera villosa, Michx.
Heuchera hispida, Pursh.
Parnassia Caroliniana, Michx.
Ribes rubrum, L., var. *subglandulosum*, Maxim.

Careful search should be made for these exceptional forms in various localities, and in any case where they are noted prompt report, accompanied by verified specimens, should be made.

THE RANGE OF THE BLUE ASH, FRAXINUS QUADRANGULATA. By W. P. SHANNON.

In Gray's Manual of Botany, edition of 1857, we have given as the range of the blue ash, Ohio and Michigan to Illinois and Kentucky. This is nearly equivalent to saying that Indiana is the center of the blue ash region. Let us look farther. In the 1868 edition of Gray's Manual we find the range given as Ohio to Wisconsin, Illinois and Kentucky. Again, in the edition of 1887, it is, Ohio to Michigan and Minnesota, south to Tennessee. In Wood's Botany, 1868, we find, Ohio to Tennessee and Iowa. In Sargent's Forest Trees of North America we find, Michigan and Wisconsin, south to northern Alabama. In Apgar's Trees of the Northern United States we find, Wisconsin to Ohio and Kentucky.

Putting together all of these definitions of the range of the blue ash we conclude that in going east from Indiana the tree disappears before we get through Ohio; in going north it disappears before we get through Michigan; in going northwest we find it beyond Illinois in Wisconsin, Minnesota and Iowa, and that it is very rare in Iowa and Minnesota; in going southwest it disappears somewhere in Illinois; in going south it becomes rare in Tennessee and disappears in northern Alabama. When we take into consideration the great prairies of Illinois, we see that Indiana is yet the center of the range of the blue ash. There is a northwestern extension around the prairie region through Michigan and Wisconsin to Minnesota and Iowa, and a southern extension through Kentucky and Tennessee to Alabama.

It would be difficult to work out the barriers that hold this tree close to Indiana. The purpose of this paper is this, to call attention to the fact that if any forest tree deserves to be called the "Indiana tree" it is the blue ash. Its range, when compared with that of other trees, is a small spot, and Indiana is the center of this spot. If this is an Indiana tree we would like to know its character when compared with other trees. It is always characterized as growing in rich soil. When a boy I heard my father say that he thought the blue ash the most beautiful tree of the forest. Frequently on looking at a large blue ash, I have thought of the truth of his judgment. From its light colored bark, with, sometimes, an imaginary blue tinge, and long straight stem, it contrasted strongly with other trees, so that the blue ash trees were bright streaks in the forest.

Among the pioneers of Indiana this tree was the choice stick for the rail fence, owing to its durability and its being easily split. A boy could make rails of the blue ash and a woman could split blue ash stove wood. Hence the blue ash soon disappeared as a large or even medium-sized forest tree. As members of the original forest, they are all gone but the scrubs. Unlike many other forest trees, the blue ash is making fair headway towards reëstablishing itself. It is an abundant fruiter, and we frequently find a young tree that has escaped the kind of civilization enforced by cattle and clean farmers.

BOTANICAL PRODUCTS OF THE UNITED STATES PHARMACOPŒIA, 1890. BY JOHN S. WRIGHT.

[ABSTRACT.]

A large number of the official organic drugs are plant products. The revisers of the United States Pharmacopœia, 1890 (published in 1894 and in effect until 1904), admit plant products, such as fruits, leaves, stems, underground portions, inspissated juices, resins, gummy exudations, products of distillation, and other materials of vegetable origin, representing 232 species, 186 genera, and 73 natural orders.

Since the pharmacopœia list of drugs is official, much care is exercised in making admissions to it. Long and general use is usually necessary to demonstrate the claim of a plant or any of its products to recognition in this work, which is the guide to druggists of the United States.

Only occasionally does an entire plant become an official drug, strictly speaking, that part only is official which is mentioned by the pharmacopœia; thus we have, under the title CAPSICUM: "The fruit of *Capsicum fastigiatum* Blume;" or as under ALOES, SOCOTRINE: "The inspissated juice of the leaves of *Aloe Perryi* Baker." In the former case it is the fruit, and in the latter the inspissated juice, only, of the plant mentioned, which is official. In some cases several parts or products of a plant are extensively employed in medicine, and may even be generally recognized in dispensatories and kindred works, though only one of these may be official; for instance, the tubers and leaves of Aconite (*Aconitum Napellus* L.) are each recognized as medical agents, yet the tuber is alone official.

With this conservatism on the part of the revisers of the pharmacopœia, it is found that nearly every official drug is of positive value in medicine, and further, that the official list is very much smaller than any other general organic drug list. As before stated, the official list includes products representing 232

species of plants, while most others will approach 700 to 1,000, and one, especially, includes the products of 2,465 species.

The 232 species yielding official drugs, with seven exceptions, belong to orders of flowering plants, and most are plants which have been long known; in proof of this, we find that many have been named by the earlier botanists, Linné being the original author of the names of 132, over half of the entire number.

The seven species which do not belong to the flowering plants represent six genera and five families, as follows:

NATURAL ORDER.	GENUS AND SPECIES.	COMMON NAME.
FILICES	*Dryopteris Filix-mas* (L.) Schott, *Dryopteris marginalis* (L.) A. Gray,	Aspidium.
GIGARTINEÆ	*Chondrus crispus*, Stackhouse, *Gigartina mamillosa*, J. Agardh,	Chondrus, Irish Moss.
LICHENES	*Cetraria islandica* (L.) Acharius,	Cetraria, Iceland Moss.
LYCOPODIACEÆ	*Lycopodium clavatum*, L.,	Lycopodium.
PYRENOMYCETES	*Claviceps purpurea* (Fries.) Tulasne,	Ergot.

Of the orders of plants represented by the official drugs, only the following five furnish ten or more species:

1. Leguminosæ . . 17 species . . . . . 12 genera.
2. Compositæ . . . . . . 16 species . . . 14 genera.
3. Labiatæ . . . . . 13 species . . . . . 9 genera.
4. Liliaceæ . . . . 11 species . . . 8 genera.
5. Rosaceæ . . . 10 species . . 5 genera.

The other 165 species are very evenly distributed among the remaining 68 natural orders.

Of the 232 species of plants which yield official drugs, there are found in North America, either as indigenous, adventive, commonly cultivated or escaped from cultivation, 134 species belonging to 110 genera and 59 natural orders. Of this number there are in Indiana 75 species representing 68 genera and 47 natural orders.

The table and statistics below show the actual and relative numbers of plants, producing official drugs, found in North America and in Indiana:

	NATURAL ORDERS.	GENERA.	SPECIES.
Entire number	73	186	232
In America	59	110	134
In Indiana	47	68	75

Of total number of species Indiana has $\frac{775}{2325}$, or about $\frac{1}{3}$.

Of total number of genera there are represented in Indiana $\frac{68}{186}$, or about $\frac{1}{3}$.

Of total number of natural orders there are represented in Indiana $\frac{47}{73}$, or about $\frac{2}{3}$.

Of American species (as defined above), Indiana has $\frac{78}{134}$, or about $\frac{5}{9}$.

Of American genera there are represented in Indiana $\frac{68}{110}$, or about $\frac{7}{11}$.

Of American families there are represented in Indiana $\frac{47}{59}$, or about $\frac{4}{5}$.

Below is given a list of plants found in Indiana which produce official drugs. The action and use of the drug also are given. For convenience, the plants are listed alphabetically under their natural orders, which also have an alphabetical arrangement.

LIST OF PLANTS WHICH PRODUCE OFFICIAL DRUGS.

NATURAL ORDER. Genus and Species.	DISTRIBUTION.	PART.	COMMON NAME.	PROPERTIES AND USES.
ANACARDIEÆ.				
Rhus glabra L.	Common	Fruit	R. glabra	Refrigerant, diuretic, astringent.
Rhus radicans L	Common	Leaves	R. Toxicodendron	Irritant, rubefacient.
APOCYNACEÆ.				
Apocynum cannabinum L.	Common	Root	Apocynum	Emetic, cathartic, expectorant, diuretic aperient.
ARISTOLOCHIACEÆ.				
Aristolochia Serpentaria L.	. . . . . .	Rhizome	Serpentaria	Stimulant, diaphoretic, tonic.
ASCLEPIADEÆ.				
Asclepias tuberosa L.	Common	Root	Asclepias	Sudorific, expectorant, carminative, anodyne.
BERBERIDACEÆ.				
Caulophyllum thalictroides (L.) Michx.	Common	Rhizome	Caulophyllum	Antispasmodic, diuretic, emmenagogue
Podophyllum peltatum L.	Common	Rhizome	Podophyllum	Alterative, cholagogue, cathartic.
BETULACEÆ.				
Betula lenta L.	. . . . . .	Oil of Bark	Oil of Betula	Antiseptic, poisonous in over doses.

LIST OF PLANTS WHICH PRODUCE OFFICIAL DRUGS—Continued.

NATURAL ORDER. Genus and Species.	DISTRIBUTION.	PART.	COMMON NAME.	PROPERTIES AND USES.
CAPRIFOLIACEÆ				
Sambucus canadensis L.	Common	Flowers	Sambucus	Stimulant, carminative, diaphoretic.
Viburnum prunifolium L.	Common	Root Bark	Black Haw	Diuretic, tonic, nervine.
CELASTRINEÆ.				
Euonymus atropurpureus Jacq	Common	Root Bark	Euonymus	Tonic, diuretic, laxative, aperient.
CHENOPODIACEÆ.				
Chenopodium ambrosoides L., var. *anthelminticum* Gray	Common	Fruit	Chenopodium.	Anthelmintic.
COMPOSITÆ.				
Arctium Lappa L. and other Sp. of *Arctium*	Common	Root.	Lappa	Diaphoretic, diuretic, alterative.
Artemisia Absinthium L	Common	Leaves and inflorescence.	Absinthium	Stimulant, tonic, febrifuge anthelmintic.
Erigeron Canadense L	Common	Herb	Oil of Erigeron	Hemostatic, irritant stimulant.
Eupatorium perfoliatum L.	Common	Leaves and inflorescence.	Eupatorium	Stimulant, tonic, diaphoretic. laxative, emetic.
Inula Helenium L	Common	Root.	Inula	Stimulant, diaphoretic, expectorant, rubefacient.
Tanacetum vulgare L.	Cultivated	Herb.	Tansy	Stimulant, tonic, anthelmintic, diuretic, emmenagogue.

Taraxacum officinale Weber	Common	Root	Taraxacum	Deobstruent, tonic in hepatic disorders.
CONIFERÆ.				
Juniperus communis L.	General, but not abundant.	Fruit	Oil of Juniper.	Stimulant, carminative, diuretic.
CRUCIFERÆ.				
Brassica alba (L.) Hooker f. et Thompson	Common near cult. ground.	Seed	White Mustard	Tonic, laxative, diuretic, sternutatory, epispastic, emetic, ext. rubefacient.
Brassica nigra (L.) Koch.	Common near cult. ground.	Seed	Black Mustard	Tonic, laxative, diuretic, sternutatory, epispastic, emetic, ext. rubefacient.
CUCURBITACEÆ.				
Cucurbita Pepo L.	Cultivated	Seed	Pumpkin Seed.	Tænifuge.
CUPULIFERÆ.				
Castanea dentata (Marshall) Sudworth	General, but not abundant.	Leaves	Castanea	Tonic, mild sedative.
Quercus alba L.	Common	Bark	White Oak	Astringent. chiefly used externally.
ERICACEÆ.				
Arctostaphylos Uva-ursi (L.) Sprengle	N. Indiana, on hills of southern part.	Leaves	Uva Ursi	Astringent, tonic, nephritic, diuretic.
Chimaphila umbellata L.	Common in rocky woods.	Leaves	Chimaphila.	Astringent, tonic, diuretic, nephritic.
Gaultheria procumbens L.	N. part of state	Oil of leaves	Oil of Gaultheria.	Stimulant, antiseptic, diuretic, poisonous in over doses.

LIST OF PLANTS WHICH PRODUCE OFFICIAL DRUGS—Continued.

NATURAL ORDER. Genus and Species.	Distribution.	Part.	Common Name.	Properties and Uses.
Filices.				
Dryopteris marginalis (L.) Gray.	Common in cool, rocky woods.	Rhizome	Aspidium	Tænifuge.
Geraniaceæ.				
Geranium maculatum L.	Common	Rhizome	Geranium	Tonic, astringent.
Gramineæ.				
Agropyrum repens (L.) Beauv.	. . . . . .	Rhizome	Triticum	Diuretic, aperient.
Zea Mays L.	Cultivated	Starch from grain	Starch	Demulcent, nutritive.
Zea Mays L.	Cultivated	Stigmas and styles (silks)	Zea	Diuretic, lithontriptic.
Hamamelaceæ.				
Hamamelis virginiana L.	Common	Leaves	Witch hazel	Tonic, astringent, sedative.
Irideæ.				
Iris versicolor L.	Common	Rhizome	Iris	Alterative, purgative, emetic.
Juglandaceæ.				
Juglans cinerea L.	Common	Root bark	Juglans	Cathartic, tonic.

LABIATÆ.				
Hedeoma pulegioides (L.) Pers	Common	Herb	Hedeoma	Carminative, stimulant, emetic.
Marrubium vulgare L.	Common	Herb	Melissa	Carminative, sternutatory, diaphoretic, emetic.
Mentha canadensis L. var. *glabrata* Benth.	Common along brooks	Stearopten from herb	Menthol	Stimulant, rubefacient, anodyne.
Mentha piperita Smith	Common, cultivated	Stearopten from herb	Menthol	Stimulant, rubefacient, anodyne.
Mentha viridis L.	General	Leaves and inflorescence	Spearmint	Carminative, stimulant, nervine.
Monarda punctata L.	Common	Herb	Thymol	Stimulant, antispasmodic.
Scutellaria lateriflora L.	Common	Herb	Scutellaria	Tonic, nervine, antispasmodic.
LAURINEÆ.				
Sassafras varifolium (Salisbury) O. Kuntze	Common	Part of root	Sassafras	Stimulant, diaphoretic, alterative, used as a flavor.
Sassafras varifolium (Salisbury) O. Kuntze	Common	Pith of stem	Sassafras pith	Demulcent.
LILIACEÆ.				
Veratrum viride Solander	General	Rhizome	Veratrum viride	Emetic, diaphoretic, sedative, irritant.
Convallaria majalis L.	Escaped from gardens	Rhizome	Convallaria.	Heart tonic, poisonous.
LINEÆ.				
Linum usitatissimum L.	Escaped from cultivation	Seed	Linseed	Demulcent.
Linum usitatissimum L.	Escaped from cultivation	Oil of seed	Linseed oil	Demulcent, laxative.

LIST OF PLANTS WHICH PRODUCE OFFICIAL DRUGS—Continued.

NATURAL ORDER. Genus and Species.	Distribution.	Part.	Common Name.	Properties and Uses.
Lobeliaceæ.				
Lobelia inflata L.	Common	Leaves and inflorescence	Lobelia.	Expectorant, nervine, purgative, emetic, narcotic.
Loganiaceæ.				
Spigelia Marylandica L.		Rhizome	Spigelia	Anthelmintic, toxic, dilates pupil.
Menispermaceæ.				
Menispermum Canadense L.	Common	Rhizome	Menispermum.	Tonic, alterative, diuretic.
Orchideæ.				
Cypripedium parviflorum Salisbury		Rhizome	Cypripedium.	Diaphoretic, stimulant, anti-spasmodic.
Cypripedium pubescens Swartz		Rhizome	Cypripedium.	Diaphoretic, stimulant, anti-spasmodic.
Papaveraceæ.				
Papaver somniferum L.	Escaped from cultivation	Concrete, milky exudation	Opium	Narcotic, sedative, anodyne, anti-spasmodic, hypnotic.
Sanguinaria Canadensis L.	Common in shady woods	Rhizome	Sanguinaria.	Alterative, tonic, stimulant, emetic, sternutatory.

PHYTOLACCACEÆ.				
Phytolacca decandra L.	Common	Root	Phytolacca root	Alterative, anodyne, resolvent, emetic.
Phytolacca decandra L.	Common	Fruit.	Phytolacca fruit	Alterative, laxative, emetic.
POLYGALACEÆ.				
Polygala Senega L.	General	Root	Senega	Expectorant, emetic, diuretic.
POLYGONACEÆ.				
Rumex crispus L. and other species of *Rumex*	Common	Roots.	Rumex.	Astringent, tonic, alterative, laxative.
PYRENOMYCETES.				
Claviceps purpurea (Fries.) Tulasne	Common in rye fields.	Sclerotium	Ergot.	Emetic, ecbolic, parturient, hæmostatic, poisonous.
RANUNCULACEÆ.				
Cimicifuga racemosa (L.) Nuttall	Common	Rhizome	Cimicifuga	Alterative, emmenagogue, sedative.
Hydrastis Canadensis L.	General, more abundant in southern p't of State	Rhizome	Hydrastis	Tonic, deobstruent, alterative.
ROSACEÆ.				
Prunus serotina Ehr	General	Bark	Wild cherry	Tonic, sedative, pectoral.
Rubus Canadensis L	General	Root bark	Rubus	Astringent, tonic.
Rubus villosus Aiton	Common	Root bark	Rubus	Astringent, tonic.
Rubus idæus L	Cultivated	Fruit	Raspberry	Refrigerant, mild laxative, dietetic.

LIST OF PLANTS WHICH PRODUCE OFFICIAL DRUGS—Continued.

NATURAL ORDER. Genus and Species.	DISTRIBUTION.	PART.	COMMON NAME.	PROPERTIES AND USES.
RUTACEÆ.				
Xanthoxylum Americanum Miller	Common . . .	Bark	Xanthoxylum	Sialagogue, stimulant, alterative, emetic.
SCROPHULARINEÆ.				
Veronica Virginica L	. . . .	Rhizome . . .	Leptandra . .	Alterative, cholagogue, cathartic.
SOLANACEÆ.				
Datura stramonium L	Common . . .	Seed	Stramonium seed	Diuretic, dilates pupil, narcotic poison.
Datura stramonium L	Common . . .	Leaves	Stramonium leaves . . .	Diuretic, dilates pupil, narcotic poison.
Nicotiana tabacum L	Cultivated in southern p't of State . .	Leaves	Tobacco	Diuretic, sedative, diaphoretic, emetic, narcotic.
Solanum dulcamara L	General . . .	Young br'nch's	Dulcamara .	Deobstruent, resolvent, alterative, anodyne.
UMBELLIFERÆ.				
Conium maculatum L	Common . . .	Fruit	Conium	Sedative, narcotic.

URTICACEÆ.				
Cannabis sativa L.	Escaped from cultivation	Female inflorescence	Indian cannabis	Anodyne, nervine, narcotic, sudorific.
Humulus lupulus L.	Escaped from cultivation	Glandular powder from strobiles	Lupulin	Stimulant, tonic, anodyne.
Humulus lupulus L.	Escaped from cultivation	Strobiles	Hops	Tonic, sedative, anodyne.
Ulmus fulva Michx.	Common	Inner bark	Elm	Demulcent emollient.
VITACEÆ.				
Vitis vinifera.	Cultivated	Fermented juice of fruit	Wine, white and red	Chiefly as a stimulant.

Noteworthy Phanerogams of Indiana. By Stanley Coulter.

Methods of Infiltrating and Staining in toto the Heads of Vernonia. By E. H. Heacock.

In beginning a study of the development of the embryo sac of Vernonia, two difficulties at once present themselves. The first is to properly stain the head in toto, and the second to infiltrate with paraffine so as to be able to section properly.

The form is an ordinary composite, having twenty or more flowers in each head. The ovary is surrounded by a thick, solid integument several layers of cells deep, and the difficulty lies in penetrating this coat.

Before staining or infiltrating, all parts of the head above the achenes were cut off, thus securing a smaller body and a more ready penetration. Heads dehydrated by 96 per cent. alcohol were washed out in distilled water, the water being frequently changed, until they sank to the bottom of the vial. They were then stained for seventy-two hours in alum cochineal (Czoker's Formulae). When sectioned they showed but a faint trace of stain. Heads dehydrated by absolute alcohol and stained for seventy-two hours in borax carmine, Kleinberg's and Delafield's hæmatoxylins gave no better results.

Heads which had been dehydrated by absolute alcohol, washed out in distilled water and stained for seven days in alum cochineal (Czoker's Formulæ) gave good results. The general tone of the stain is dim, but under high power the differentiation is very fine. Heads dehydrated by absolute alcohol and stained for seven days in borax carmine gave very fair results. These results point to the fact that with long time treatment the heads may be successfully stained.

The second difficulty: infiltrating with paraffine. The first medieum used was turpentine. Heads dehydrated by 96 per cent. alcohol were placed in turpentine for twenty-four hours, then into a mixture of one-half turpentine and one-half paraffine for twenty-four hours, thence into pure paraffine (48° C.) for twenty-four to forty-eight hours. On sectioning the sections were found to tear out in the center, thus proving that paraffine had not reached the center of the head. Heads dehydrated by absolute alcohol were given the same treatment. In this series the small heads showed an improvement, but still the normal sized heads were not properly infiltrated.

The next medium used was a mixture consisting of one-half cedar oil and one-half xylol. Heads dehydrated by absolute alcohol were placed in this medium for twenty-four hours, then into a mixture of one-half the medium and one-half

paraffine for twenty-four hours, then into pure paraffine (48° C.) for twenty-four hours. On being sectioned this material showed but little, if any, improvement over the material treated with turpentine.

The next medium used was xylol. Heads dehydrated by absolute alcohol were placed in xylol for twenty-four hours, then into a mixture of one-half xylol and one-half paraffine for twenty-four hours, then into pure paraffine (48° C.) for twenty-four hours. When sectioned on a Heidelberg microtome the heads were found to be well infiltrated and made fine ribbons. A series of experiments was then begun on heads dehydrated by absolute alcohol, giving them shorter time periods. It was found that heads treated with xylol for three and one-half hours, then to a mixture of one-half xylol and one-half paraffine for two hours, then to pure paraffine (48° C.) for two and one-half hours, were infiltrated, and sectioned just as well as heads which had had the extended time treatment.

The conclusions to be drawn seem to be, first, that large heads of composites may be stained successfully in toto, but to insure success a long time is necessary. Incidentally it may be said that, so far as tests made have gone, alum cochineal gives decidedly the best differential stain.

Second, that successful infiltration can be made in a time as short as eight hours by the use of xylol, a longer treatment being unnecessary. That a treatment with turpentine and a mixture of cedar oil and xylol, as far as Vernonia is concerned, gives unsuccessful results with the normal sized heads. Cedar oil alone was not tried, nor are the experiments as to methods yet completed. They are given, however, in the hope that suggestions may be made that will extend their scope and lead to more definite conclusions.

EMBRYOLOGY OF THE RANUNCULACEAE. BY D. W. MOTTIER.

CERTAIN CHEMICAL FEATURES IN THE SEEDS OF PLANTAGO VIRGINICA AND P. PATAGONICA. BY ALIDA M. CUNNINGHAM.

In the study of the genus *Plantago*, to ascertain the value of seed characters in determining specific rank, the peculiarities hereinafter described were noticed as among the results of some of the experiments. These results, in themselves, are perhaps of little or no value in determining the question under investigation, yet, they are so closely connected with the experiments, and altogether so peculiar as to warrant a somewhat extended research.

In the study of the seed characters of the genus *Plantago*, particular attention was given to outline and to the structure of the seed-coat, and it was necessary to make cross-sections of the seeds of each species. Preliminary to this the seeds of each were placed in water for a few hours, in order that they might be more easily sectioned, when the peculiar development of a blue color in *P. Virginica* was noticed. It was thought, at first, this might be due to some substance contained in the water used, so the experiment was repeated, using distilled water with the same unvarying results.

An examination of literature showed that, in all probability, it was a glucoside allied to Indican. This was further rendered probable because such substances are found in widely separated families, as *Euphorbia tinctoria*, and *Polygonum tinctoria*.

The indigo plant is destitute of color until treated with water. The broken and bruised plants are placed in vats, covered with water and allowed to ferment, and the indigo separates from the plants and is precipitated. Indican is soluble in boiling ether, boiling alcohol, glacial acetic acid, carbolic acid, petroleum, chloroform and hydrochloric acid

The seeds of *P. Virginica*, when dry, are golden yellow in color, and the cross section showed the cell contents to be colorless. Within three hours after being placed in water they had turned black on the surface, but an examination of a cross section showed the cell contents of the entire seed coat, except the outer row, the cell contents of the cotyledons and even the cell walls to be a bright blue color. Since this color was developed in a similar way to that by which Indican is produced, the tests for Indican were tried, giving the following results: After the color had been developed by water, thin sections were placed in 96 per cent. alcohol and boiled for ten minutes with no perceptible change. Sections were boiled for three minutes in ether without any change in color. Others were kept in glacial acetic acid for two hours with no change. Sections were kept in petroleum for twenty-four hours, and within that time the blue color was destroyed, leaving the cell contents colorless. The blue remained unchanged after a two hours' treatment with pure chloroform. Sections were kept in carbolic acid for two hours with no perceptible change. Hydrochloric acid destroyed the blue color within ten minutes, and left the cell contents colorless. After comparing these results with those of Indican, it was found that this blue substance in the seeds of *Virginica* resembles Indican in that it is developed in the same way and gives the same reactions with nitric and hydrochloric acids, sodic hydrate and petroleum. It differs from Indican, however, in being insoluble in boiling ether, boiling alcohol, glacial acetic acid, carbolic acid and chloroform.

In order to determine whether this substance was insoluble in presence of water, dry seeds were kept in cold alcohol for twenty-four hours, and during that time there was no change either in the color of the seeds or in the cell contents. The seeds were taken from the alcohol and placed in water, and within three hours they had turned black, and the blue was developed in the cells. Dry seeds were placed in glacial acetic acid, and within twenty-four hours they were turned a light yellow color and sections showed the cell contents to be colorless. These seeds were taken from the acid and kept in water for twelve hours, and during that time no further change took place. Dry seeds were placed in strong ammonia, and within twelve hours they had turned black on the surface and the cell contents were turned brown. After this treatment with ammonia, the seeds were kept in water for several hours, but no further change was perceptible. The dry seeds were kept in pure chloroform for three days, and during that time they retained their golden yellow color and the cell contents also remained colorless. Then they were taken from the chloroform and placed in water, and within three hours they had turned black, and the blue was developed in the cells.

After the color had been developed by water, sections were treated with nitric acid, and the blue color disappeared immediately, leaving the cell contents a yellowish brown color. The blue was turned green immediately upon being treated with sodic hydrate, but was changed to blue again within twelve hours after being placed in glycerine. On account of the small amount of material it was impossible to carry these experiments to a conclusion.

A blue substance is developed by water in the seeds of *P. Patagonica* also, but no chemical experiments were made upon these seeds.

P. Virginica and *P. Patagonica* were the only species examined in the genus *Plantago* which showed this peculiar development of color.

The test for this substance in the indigo plant itself was made upon an herbarium specimen and failed to produce it. The indigo plant must be taken at certain stages of its development in order to produce Indican, and such may be the case in *Plantago Virginica*.

Root System of Pogonia. By M. B. Thomas.

The genus Pogonia is a remarkably interesting group of orchids represented by five species in northeast North America out of a total of forty-three in the whole genus.

The species have a very wide distribution, being found throughout North America, Africa, eastern Asia, and, to a very limited extent, throughout Europe.

Notwithstanding the wide distribution, the species seem to have a remarkably similar habitat, and consequently the plants show a very striking resemblance in regard to their structure and adaptation to their rather peculiar surroundings. The plants of the genus are all found in low, damp places, with an extreme reached in *P. ophioglossoides*, which grows in sphagnum bogs throughout North America, Japan and Europe. With reference to the other North American species of Pogonia no marked variation from the regular terrestrial orchids has been observed which would indicate that the plants had undergone any special or irregular variations as a result of their peculiar environments.

In an examination of the roots of *P. ophioglossoides* it was found that a striking exception existed which might be a very suggestive one when considered from the standpoint of the adaptation of the plant in order to better fit it to withstand the peculiar difficulties of its surroundings.

The roots of all phanerogams are provided at the tip with a series of initial groups, from which differentiate the various parts of the root in the following order: From the calyptrogen comes the root cap, from the dermatogen the epidermis, from the periblem the cortex, and from the plerom the central cylinder. Sometimes one or more of these groups are combined and this is the condition ascribed by Trent to the orchidaceæ, regarding which he holds that the calyptrogen is not present and the root cap and epidermis originate from a common initial group, the dermatogen. Janczewski holds that in these monocots we find a well marked calyptrogen, and in this he is supported by Flahault and others.

With reference to this arrangement, in the roots of *P. ophioglossoides*, was found what is believed to be a marked exception to all phanerogams, except possibly a few parasitic ones.

The roots of the plant are small, very long, much branched, and provided with a few root-hairs. At the tip we find an entire absence of a root-cap, and the cells of the dermatogen, with but slightly thickened walls, form the outside covering, which in the growing plant is quite green.

The cells of the dermatogen undergo a periclinal extension 2-8 mm. back from the tip, and at this point they quickly change into the more firm, brown epidermis which soon shows the differentiation of the root hairs. The dermatogen cells are very large, regular and with conspicuous nuclei showing great activity.

Another condition not seen in other roots is the very rapid development of the fibro-vascular bundles from the procambium which usually extends some distance back from the tip, and from it very gradually differentiate the elements of the fibro-vascular system, whereas in *Pogonia ophioglossoides*, the xylem shows reticulated tracheids often not more than ten cells back from the initial group of

the plerom. The arrangement of the parts of the central cylinder shows the regular differentiation of the radial bundle of roots.

It might at first be supposed that *Pogonia ophioglossoides*, like many plants (*Azolla*, *Hydrocharis*, *Ranunculus*, *Ficaria*) having roots with a limited growth, throws off its root-cap. but such is not the case, since not even the rudiment of one is developed, and the secondary roots break through the cortex and epidermis without any covering to their tip. Neither is the absence of the root-cap in any way comparable to the condition found in some Aroids, *e. g.*, *Anthurium longifolium* (Bot. Zeitung, 1878, p. 645,), where the root-cap is torn away and the root, by the production of a bud at its tip, developes into a shoot, and in this way continues its growth.

Of the constancy of the peculiar condition in *Pogonia ophioglossoides*, there seems to be no doubt, since it is found to be true of plants collected in various parts of the United States, and growing under somewhat different circumstances. The condition is then something more than accidental. The structure of the root, so far as the apex is concerned, is then not unlike that of the stem of many water plants (*Hippuris vulgaris*), where a single layer of dermatogen covers the tip, and inside of this, 5-6 regular isodiametric cells of the periblem, which undergo periclinal division, give rise to the cortex. Inside of this, is a group of 4-5 initial cells of the same character giving rise to the fibro-vascular system.

The meaning of this variation and its value to the plant is not certain, but it is suggested that, since the plant grows in loose sphagnum and the roots are not in any immediate contact with the material from which they draw their food supply, the tip of the root pressing constantly against the decaying stems of the moss is a very important factor in the absorption of food. Protected, as it usually is in other plants, with a root-cap, the outer cells of which are not capable of becoming turgid, the efficiency of this part of the root is very seriously interfered with for the absorption of food. With most plants, where the whole length of the roots is in immediate contact with their source of food supply, the work done by the root hairs does not make necessary the use of the tip for absorptive purposes. Neither does *Pogonia ophioglossoides* have the advantages of a water plant, which, like *Pontederia crassipes* and many floating plants, take up their nourishment from the free water through the agency of the great mass of root hairs, often so strikingly developed. In *Pogonia ophioglossoides* only those parts of the root that are here and there in contact with the stems of the sphagnum are able to take up food. The necessity of a large absorptive surface to the root system is more apparent when we consider that, contrary to the general opinion, the bog soil is not rich in nitrogenous material.

Another and stronger proof that the tip of the root is so valuable an absorptive organ is the extraordinary development of the conductive tissue of the root to a proximity of the tip wholly unlike that found in other plants. This unusual development would indicate that the plant obtained through the vascular tissue from the tip a part of its food supply. Such a condition of unusual development of vessels at unexpected places is to be noted in various plants, and indicates the dependence on that part for supplies of moisture. This is true, for example, of those parts of pitcher plants that retain supplies of water, without which the plant would wilt. (King and Zimmerman, 1885.) On the other hand, aquatic and semi-aquatic plants often show poorly developed root-caps, or frequently the cap is attached only at the very tip, thus allowing the water free contact with the epidermis, but a few cells back from the initial group.

The need of the root cap as an organ of protection in *Pogonia ophioglossoides* can certainly not overbalance the increased efficiency of that part of the root due to its absence. The loose nature of the sphagnum does not offer any resistance to the growing root, while it at the same time affords an efficient protection. It is true that aërial and aquatic roots are not required to force their way through the medium in which they grow, but at the same time the air and water do not protect the roots as does the moss, and, further, in the case of aërial orchids the outer cells of the root cap do not drop away to any great extent, and the whole tip of the root may become turgid and capable of absorbing moisture, thereby accomplishing the same end in this respect as would be reached were the root cap not present. No doubt the increased activity of the tip would make it more sensitive, and, as the recent investigations of Pfeffer (Annals of Bot., Sept., 1894,) show the irritability of the root to be confined to that part, this would certainly be of great advantage to the plant.

It would seem, in view of what has been said, that the absence of this cap in *Pogonia ophioglossoides* is not the effect of degeneration, but rather the attainment of a greater stage of perfection, true to the principles of evolution, whereby a useless organ has degenerated and disappeared, and in so doing worked material advantage to the organism.

SALT-RISING BREAD. BY KATHERINE E. GOLDEN.

Notes on Florideæ. By Geo. W. Martin.

Of the two orders comprising *Rhodophyceæ*, *Florideæ* is the most noteworthy. The number of species composing it is large, all of which have the predominating red shade in their normal condition, though other colors are sometimes very conspicuous. Like other noted cases, the order seems to be a very natural one; in fact, the genera and species graduate into one another so finely that sharp distinctions can not be obtained. However, it must not be inferred that exceptions do not occur here as is common to the other natural divisions of the plant kingdom. With the exception of a few genera, such as *Batrachospermum*, *Lemanea*, *Bangia*, *Chantransia* and *Hildenbrandtia*, all are marine; their favorite place of growth is below low-water mark and in deeper water, but some forms are found in tide pools.

Both morphologically and physiologically, by many it is claimed that this *order* exhibits the highest characters known to algæ. The structure of the frond varies with the genera; in some the tissues are very simple; in others very delicate and complex. All plant bodies are multicellular, and present a variety of forms: some are *filamentous*, either monosiphonous, as in *Ceramium*, or polysiphonous, as in *Polysiphonia*; growth is by means of an apical cell; others are *membranaceous*, formed by branching filaments cohering and the filling up of mucilaginous substance between; in the latter, growth results from a division of marginal series of cells.

While considerable variety of forms and complicated structures obtain in the *Florideæ*, *the most noteworthy characters* to be brought out are the methods of reproduction; namely, *vegetative multiplication* and *spore reproduction*. Of the former, many methods are purely vegetative, among which, reproduction by multicellular gemmæ being the most rare, such as found in *Melobesia*. Non-motile cells from terminal cells of branches are thrown off, and to all appearances represent a kind of transition stage between the purely vegetative and the spore-reproductive. Of the latter, two divisions occur; namely, the *non-sexual* and the *sexual-spore* reproduction. The non-sexual spores are formed either *sexually* or *asexually*; the former are always reproduced by the *sporophyte*, and known as carpospores, while the latter are formed by the *gametophyte*, and known as gonidia, or ordinary spores. These are produced in unilocular sporangia, as in *Ceramium*, or in multilocular sporangia, as in *Dasya*.

These bright red, motionless spores are divided into three classes, viz., *tetraspores*, which may be cruciate, zonate or tripartite, *polyspores* and *sierospores*. The latter are common to species of *Ceramium* and *Callithamnion*, and consist of chains of oblong cells formed directly from the branches at their extremities. The

arrangement of the sporangia on the fronds is various. In some cases, as in *Dasya elegans*, they are limited to particular portions of the frond, borne on modified, lateral pod-like branches, so-called stichidia, the terminal cells of which give rise to sporangia. In others, as in *Polysiphonia*, they are developed internally, within the superficial cells, and are either isolated or collected in wart-like masses, *nemathecia*. The latter method seems to prevail among the genera. The fronds bearing the tetraspores are, with few exceptions, distinct from those bearing sexual fruit or cystocarps. Occasionally both tetraspores and cystocarps are found on the same specimen, as in certain species of *Callithamnion* and *Spyridia*. The tetrasporic plants are decidedly more abundant than the cystocarpic. In certain genera, among which *Callithamnion*, it is not uncommon to find *antheridia*, *cystocarps* and *tetraspores* on the same individual, a thing rarely to be seen in the *Florideæ*. But the most puzzling part of the whole life history of the order is the complicated process of sexual reproduction. In many cases the full development of the cystocarp is unknown. Many details connected with the act of fertilization are as yet very obscure. To account for all stages from procarp to cystocarp is at present a problem of extreme interest among algologists.

The organs of sexual reproduction include the antheridium and the procarp, the latter comprising the *trichophore* and the *trichogyne*. As a rule, the sexual cells are terminal in position and more or less fixed, usually placed on the youngest lateral branches of the frond, and are either unicellular or multicellular, thus forming clusters.

A brief description of the simplest arrangement to effect fertilization is the following:

The terminal cells of two lateral branches become changed in form and structure; the one, tuft-like, the antherid, contains a simple non-motile, nonciliated antherozoid; the other, a terminal cell, with two below forming the procarp, enlarges and elongates above to form a long, slender, hyaline hair, the *trichogyne*, whose basal portion is the *trichophore*. In the simplest forms, as in the *Bangiaceæ*, the antherozoids come in contact with the extremity of the receptive trichogyne where they adhere for a time. After the walls of both points in contact are absorbed, the fertilizing influence is propagated through the trichogyne to the trichophore, which enlarges by cell division. In this case the trichophore becomes the carpogenic cell, which subsequently divides, each *division* yielding a carpospore. Such a product of fertilization is a *cystocarp*, whose formation is direct. Other cases of direct formation occur, as in *Nemalion* and *Chantransia*, where the carpogenic cell gives rise to an outgrowth of oöblastema filaments whose cystocarps consist of clusters of sporangia. In by far the greater number

of genera the cystocarps are not formed by direct, but by indirect, outgrowths from the trichophore. For example, in *Callithamnion*, the fertilizing substance passes from the trichogyne, if at all, through the *trichophore* and *sometimes several cells below*, before certain lateral cells are reached, which become spore bearing. In *Dudresnaya* the trichophore of one procarpic filament gives rise to several lateral tubes, itself becoming non-spore bearing, which convey the fertilizing impulse to certain cells of other procarpic filaments which have no trichogyne in other parts of the frond. Thus, cystocarps are formed at great distances from the trichogyne. In *Polyides* a similar arrangement obtains, but the cystocarps are not the auxiliary cells of the procarpic filaments; they are lateral expansions of the trichophoric tubes. In other genera, the evidences are ample to disprove the act of fertilization. In *Ptilota serrata*, as far as observations went, I found the antheridial plants very rare. Not a single antheridial plant or an antherozoid was found in contact with the trichogyne. A very peculiar phase in the development of the cystocarp was noted a trichophore with five trichogyns; the antherozoids would have had to pass through two, in some cases three, cells to have fertilized the lateral carpogenic cells.

In *Batrachospermum*, the carpogonium develops cystocarps without any connection with the trichogyne—an entirely non-sexual process. A cellulose plug separates the trichogyne from the trichophore. In *three* species of this genus cellulose plugs were constant, and two nuclei in the trichogyne. Only about 10 per cent. of specimens examined showed evident fusion of antherzoids with the carpogonium. The oöblastema filaments are not outgrowths of the carpogonium, but from cells below, which is in opposition to Thuret and Bornet. Physiologically, then, two great types of reproduction seem to occur: one in which cystocarps develop from the carpogonium; the other in which cystocarps develop from the cell below.

To sum up the sex phase of Florideæ: Antherozoids very rare, non-motile and in some cases wanting. Only a very few cases of actual fertilization recorded by algologists. Not definitely known whether antherozoids fuse with carpogonia or whether apogamy is the rule. The commingling of the nucleus of the antherozoid with the nucleus of the trichogyne and the contents separated from the carpogonium by a cellulose plug—a hint, no doubt, toward an old hereditary act of ancestral forms.

Therefore, the strongest point in the investigation of the *Florideæ* is the separation of the trichogyne from the trichopore, and fertilization not accomplished.

MEASUREMENTS OF STRAINS INDUCED IN PLANT CURVATURES. BY D. T. MACDOUGAL.

THE STOMATES OF CYCAS. BY EDGAR W. OLIVE.

THE BUCKEYE CANOE OF 1840. BY W. P. SHANNON.

One of the campaign devices of 1840, in this State, was a buckeye canoe on wheels. General Harrison, the Whig candidate, was a citizen of the Buckeye state and the hero of the battle of Tippecanoe. Hence, the Buckeye Canoe embodied the ideas that caught the selfish pride of two states. The purpose of this paper is to give some idea of the size of the tree from which this canoe was made.

The dimensions of the canoe and of the tree were given to me by Mr. Robert Cones, of Muncie, a man that I have known all my life, and his statements agree well with those that I have obtained from others. Mr. Cones was one of those who guarded the canoe of nights, while it was being made. It was fifty feet long, well dressed both outside and inside. On the inside, boards were placed crosswise for seats, and three persons could sit comfortably on one seat.

During the campaign it was hauled from place to place over the state, appearing at Indianapolis, at Richmond and the Battle Ground. The dimensions of the canoe show that the tree was immense. We have seen yellow poplar or tulip trees big enough for such a canoe, but it hardly seems credible that there ever existed such a buckeye ree.

The tree, standing, measured 27 feet 9 inches in circumference at two feet from the ground, and was 90 feet from the ground to the first limb. The foliage was reduced to a bunch at the summit of the stem, which caused some who saw the tree to compare it to the palmetto. The tree had no spur roots, it stood in the ground like a post, it was as straight as an arrow and held its thickness remarkably well. This tree grew in the southeast corner of Rush County, and was recognized as a sweet buckeye. If so, it was *Æsculus flava*. On account of its size and majesty it was known far and wide, and was visited as a great curiosity by men from different parts of the United States. Occasionally a man from a distant city, a merchant from Philadelphia, for instance, having business in Connersville, Brookville, or Rushville, would drive from 10 to 15 miles to see the "Big Buckeye."

I have never found *Æsculus flava* in Decatur County, a region where I have given some attention to the forest trees. It is not in Mr. Meyncke's published

list of the Phanerogams of Franklin County. It does not appear in the catalogue of Indiana plants published in connection with the Botanical Gazette a few years ago, in 1882, I believe. But according to Dr. Collins it occurs in Dearborn County. Dr. Phinney places it among the forest trees of Delaware County. It has been reported, I know not by whom, from Jefferson County. Hence Rush County seems to be in the region inhabited by the Sweet Buckeye.

The comparative sizes of *Æsculus glabra* and *Æsculus flava*, as given by the authors, is good evidence that the tree in question was *Æsculus flava*, and not the common buckeye, *Æsculus glabra*. According to Gray, *glabra* is a large tree, and *flava* a large tree or shrub. According to Wood, *glabra* is a small, ill-scented tree, and *flava* a large tree, 30 to 70 feet high, common in the southern and western states. Then he adds by way of parenthesis: In Columbia County, Georgia, only 4 to 6 feet high. This seems to explain the shrub of Gray, and indicates that it is not only an extreme, but narrowly local variety. In Sargent's Forest Trees of North America, *glabra* is a small and medium-sized tree, and *flava* a tree sometimes 60 feet in height, with a trunk 2 to 3 feet in diameter. According to Apgar, *glabra* is a small to a large tree, sometimes only a shrub 6 to 7 feet high, and is found from Virginia to Indiana and southward.

If this big buckeye was *Æsculus flava*, and the evidence shows that it was, we have an example of a gigantic individual growing near the limits of the range of the species.

Embryo Sac of Jeffersonia Diphylla. By Frank M. Andrews.

Some Notes on the Ameba. By A. J. Bigney.

Students and teachers in biology usually have considerable difficulty in finding an abundant supply of this interesting little animal. The directions generally given in our text-books will enable one to find plenty in the course of time, but the teacher does not have very much time to devote to this part of the work, and in many cases the animal must be omitted because it can not be found when it is needed.

I hope that no member of this Academy has ever had any difficulty in this line, but I fear my wish can not be realized. It may be that the method of finding them here presented is not new to this Academy, but I have not as yet met with it after examining almost scores of texts and talking with many of the leading biologists of this country. If it be old to some, it will be new to others.

While collecting for the biological department of the Johns Hopkins university, I put a small quantity of *Euglena* in a bottle and kept it on my desk. In a few days I examined it and found amœba in great numbers.

To those who are not acquainted with the *Euglena*, permit me to say that it is a small plant which passes its motile stage on the surface of ponds in most parts of this country. After remaining in this condition a few days--the surface of the pond being quite green with them—they pass into the resting stage and disappear, the surface of the pond becoming clear, but in a few days more the pond will be green with the motile forms. This seems to be a remarkably favorable habitat for the amœba. They are near the surface so that they can secure plenty of oxygen, and the surroundings are such that the other conditions of life are exceedingly good.

When the above material was first examined they were multiplying very rapidly, but in a few weeks the conditions changed somewhat, so that there were more large ones.

This supply was secured in November, 1893, and was the source of supply for the university the remainder of the year. When I left, late in May, 1894, there were as many as ever and in good condition. They were so abundant that often two or three dozen could be found on a single slide.

On my return to Indiana, I found plenty of *Euglena*, and likewise a good supply of amœba. In September I furnished my class with this material, and they met with practically no difficulty in finding them, for they were so numerous.

A little later I collected some of the *Euglena* from a pond of strong manure water in a barnyard, and the usual numbers were found.

A few days ago, on examining the same material, I found them more abundant than ever before.

By this method I feel sure that teachers can always obtain amœba without any difficulty.

The Variations of Polyporus Lucidus. By L. M. Underwood.

[Abstract.]

The above species is common to both Europe and America, and as usually reported is a fungus that inhabits the dead portions of conifers, notably in our northern regions the hemlock. It is also in northern regions a stipitate species, having a lateral stem and is, moreover, annual. I find that in lower latitudes it departs from all these supposed characteristics. (1) It grows on the wood and at the roots of deciduous trees. (2) It is often sessile or has an irregular stem.

(3) It is perennial and even stratose, *i. e.*, forms a succession of layers of pores. Specimens from South Carolina and Indiana exhibit the latter condition. The species has been regarded as the type of a distinct genus, *Ganoderma*. It is possible that the supposed variations represent incipient and, perhaps, distinct species, yet the group in which the species occurs thoroughly defies all exact classification, a single species often in its variations overreaching generic and even family limitations.

THE PROPOSED NEW SYSTEMATIC BOTANY OF NORTH AMERICA. By L. M. UNDERWOOD.

[ABSTRACT.]

Announcement of a new flora of North America, to be the combined work of the leading botanists of the country. Each group is to be monographed by specialists. The work is to consist of seventeen volumes octavo, of about 500 pages each and to be issued in parts. Separate parts of the work will also be obtainable, but at an advanced price.

CELL STRUCTURE OF CYANOPHYCEÆ. BY GEO. W. MARTIN.

Contributions on the *cell structure of algæ plants* have by no means reached a considerable degree either in point of number or in scientific results. Research in this line is comparatively an untried field; especially does it obtain in reference to the class of algæ known as the *Cyanophyceæ*.

During the past summer the writer had an opportunity of studying *marine* as well as *terrestrial* forms of a number of species. Work was undertaken, chiefly, to discover, if possible, by use of various reagents, any method that might lead to the identification of constituent and structural parts composing the cell. The following is a brief *resumé* of the results obtained:

Chromatophore. It appears to consist of colored bodies, so-called "grana," embedded in a homogeneous, colorless, ground substance. The grana are bound together by a connecting substance into a moniliform, or necklace-like fibrillæ. These are denser near the surface and run more or less spirally around the cell. Just here may be mentioned the fact that the fibrillar arrangement of the grana is denied by Palla.

In all cases observed, the chromatophore is *parietal and continuous*, and is separated from the wall by a delicate layer of protoplasm. In several instances it appeared to be vacuolate.

Central Body. On treatment with methylene blue a central body appears; it takes a living stain, is more or less rounded and central in the cell. According to the investigations of Palla it is homogeneous, but according to Hieronymus it is more or less differentiated into granules, having a fibrillar arrangement. The fibrillæ, however, are not surrounded by a membrane, and may extend in any direction throughout the cell, even penetrating the chromatophore. The granules are strikingly significant of the cyanophycin grains of Hieronymus. Though the central body in its reaction towards stains, etc., yields results similar to those of nuclei, yet it does not appear to be a nucleus, or at any rate it does not show in detail the characteristics of a nucleus, *as found in the higher plants.*

Mucus Globules. In the parietal part of the cytoplasm of most species occur globular structures which are most numerous along the septa. In appearances they harmonize with the description of Schmitz's mucus-globules. But according to the investigations of Hieronymus they are identical with cyanophycin grains. There is no similarity in results, for mucus globules are insoluble in hydrochloric acid and stain with methylene blue, while cyanophycin grains are soluble in hydrochloric acid and do not stain with methylene blue.

Vacuoles. Irregularly distributed through the contents of the cell are usually a number of transparent spaces of cell sap or vacuoles. They vary in size and in number.

Oil. Drops of oil were observed in the germinating spores of *Glœotrichia.*

The Cell Wall. The structure of the cell wall presents, to a slight degree, a form of lamination. It is of comparative thickness, and more or less colorless. As to its chemical composition, the results obtained by the application of acids and stains were too fragmentary to draw any satisfactory conclusions. However, I found it highly resistant on treatment with acids, especially 33 per cent. chromic and concentrated sulphuric. With the anilines very decided stains were obtained. In short, of the five recognized kinds of cell walls, one type possesses properties intermediate between those of *fungus-cellulose* and *cutin.*

The Sheath. Peripheral to, and conjunctive with the cell wall is the delicate, membranous sheath. In some species the sheath is wanting, but in most cases it is present and marked by varying degrees of thickness, even at times giving a stratified appearance. Chemically, it differs considerably from the cell wall, but it is closely allied to cellulose. In many cases it turns blue on treatment with chloriodide zinc; is mostly soluble in sufficiently concentrated chromic and sulphuric acid, but is insoluble in cupra-ammonia. Agreeing with cellulose, it, too, possesses the property of cuticularization.

PRELIMINARY ACCOUNT OF THE DEVELOPMENT OF ETHEOSTOMA. BY A. B. ULREY.

EMBRYOLOGY OF THE CUPULIFERÆ. BY D. W. MOTTIER.

VARIATION IN ETHEOSTOMA. BY W. J. MOENKHAUS.

BLOOD CORPUSCLES OF THE VERY YOUNG HUMAN EMBRYO. BY D. W. DENNIS.

EMBRYOLOGY OF THE FROG. BY A. J. BIGNEY.

The embryology of the frog is an old subject, yet few of our smaller institutions and many of the larger colleges and even some universities often do but little work on the frog in this line. The material is so abundant that it seems that it ought to be studied some at least even in our high schools. One difficulty in the way, and perhaps the greatest, is a good method of manipulation. Many find this trouble and give up almost in despair.

It is the chief object of this paper to present what I consider the easiest and best method of manipulation. By this method even the inexperienced student or the amateur may soon be able to do fairly good work.

Eggs obtained very early in the morning may show the first process in maturation, viz.: the formation of the polar bodies. This can be observed better in the Amblystoma, or even more easily in the common pond snail, the *Dymnaeus* or *Physa*.

In order to preserve the eggs for permanent mounting or sectioning, they should be killed and partially hardened in alcoholic-picro-sulphuric acid. The alcohol used in this solution should be 30 per cent. The eggs should remain in this solution from six to twelve hours, depending upon the age of the egg. Before putting them in this solution, most of the gelatinous substance should be removed by a needle or similar instrument. Next wash a few minutes in 30 per cent. alcohol, then transfer to 50 per cent. for an hour, then to 70 per cent. for two to four days.

The 70 per cent. alcohol passes through the membrane covering the egg and pushes it a short distance from the egg proper, so that it can easily be clipped with a pair of sharp scissors, and the egg is readily removed. If the alcohol is much

stronger than 70 per cent. it will not cause this swelling of the membrane. After this the eggs can be dealt with after the regular methods.

To study the segmentation the eggs may be kept in a watch-glass, and examined with a strong lens or low power of the microscope. The formation of the furrows can be studied up to the 32-celled stage with practically no difficulty, and with some care to the 128-celled stage. Eggs at the various stages may be killed, hardened and sectioned so as to show the internal changes, the formation of the cleavage cavity, the archenteron, notochord and other organs that appear from time to time. In the process of clearing the eggs it is best to use cedar oil rather than turpentine, for the latter tends to make them even more brittle than they are.

The general progress of this development is too well described in text-books to merit any further account here. I am indebted to Prof. Th. H. Morgan, of Bryn Mawr college, for most of the above points. I have carefully tested them, and can recommend them without restricting qualifications.

Another interesting field in the study of these eggs is to separate the segments in the early stages of segmentation and observe the result. It has been found that in the two-celled stage each segment will form a perfect animal, but only about half the normal size. This has been tested as far as the eight-celled stage, each segment continuing its development, but forming specimens much smaller than ordinarily, the effects of pressure upon the developing eggs causing them to segment in a different manner. Other points of interest might be suggested, but these are sufficient to call attention to this important subject.

POISONOUS INFLUENCE OF VARIOUS SPECIES OF CYPRIPEDIUM. By D. T. MACDOUGAL.

At the last December meeting of the Academy a short paper was presented by the writer detailing some observations tending to show that *C. spectabile* and *C. pubescens* have an irritant action on the human skin. This paper was printed in full in the "Minnesota Botanical Studies," Part 1, 32, 1894.

The interest in the matter shown by the comment of the scientific and daily press and by the large amount of correspondence received, was such that a series of tests were planned which would place the entire matter beyond all question or doubt.

It had been suggested by ingenious correspondents that the poisonous effects experienced by the writer in handling *C. spectabile* in a swampy location, may have been due to the action of some of the poisonous plants, such as *Rhus*, usually

found in or near sphagnum swamps. When it was found by careful examination that no plants of the genus *Rhus* grow within one mile of the locality in which the test was made, one of my correspondents, with a most admirably developed "scientific imagination" suggested that the pollen of the *Rhus* may have been carried by the wind and caught by the secretions of the glandular hairs, in such quantity that the amount of toxicodendric acid contained would be sufficient to produce the irritant effect.

A number of root clumps of *C. spectabile*, *C. pubescens* and *C. parviflorum* were obtained from Pitcher and Manda, and placed in the plant house under such conditions that leafy stems were formed and the experiments could be carried on at intervals from February 1 to June 1, 1894. In the plant house were no other known plants of poisonous influence, and since during the greater part of this period the country around Minneapolis was covered with snow to the depth of two or three feet, all danger from distant *Rhus* clumps and sphagnum swamps was held to be fairly excluded.

Detailed tests with the leaves of *C. spectabile* rubbed lightly on the skin of the wrist, arm, face or ear, were made with nine persons; of these, six were "poisoned" in a degree corresponding to the manner of application, in a time varying from ten to twelve hours. By a canvas of the students of the department it was found that nearly the same percentage were usually poisoned by *Rhus*. In order to confirm these results the test was repeated with the same result. Still farther repetitions were made by some of the persons concerned, until no question as to the result remained. The unpleasant effects of these tests were a severe drain on the enthusiasm of the subjects, and the later tests on three persons made with *C. pubescens* were equally marked. Nor is it a matter of surprise that similar effects were shown by *C. parviflorum*. It was next in order to ascertain whether this effect was due to the mechanical injury resulting from piercing the skin by the pointed hairs or to the corrosive action of the secretion found on the outside of the globular tips of the glandular hairs. To this end separate tests were made by material from *C. spectabile*. The hairs of each kind were taken from the leaf by means of a pair of fine forceps and the tip pressed against the skin. Irritation resulted from the contact of the glandular hair only, and in the form of a red macule 1 to 2 millimeters in diameter.

It was found, further, that the irritant action of the plant increased with the development of the plant, and reached its maximum with the formation of the seed-pod, from which it seems entirely reasonable to infer that this is a device, and a very efficient one, for the protection of the reproductive bodies during the period from pollination to the maturity of the seeds.

DEVELOPMENT OF SEXUAL ORGANS IN CYMOTOGASTER. BY C. H. EIGENMANN.

[ABSTRACT.]

Reproductive cells are segregated very early before any protovertebræ are formed, and the embryo is no more than .3 mm. in diameter. About a dozen cells are present at this early time. These migrate backward with the growth of the embryo, but do not share in the general development. When the larva has attained a length of 7 mm. the cells begin to divide, and by the time the larva has reached a length of 8 mm. all have undergone division, so that about 24 cells are present. These are arranged in a V shaped area. The arms are formed by the folds in the peritoneum in which the sex cells lie.

The sexes become differentiated when the larvæ have reached 10 mm. The differentiation becomes apparent in the general shape of the reproductive glands before any difference is noted in the reproductive cells.

At 20 mm. the grouping of the cells has become characteristic of the sexes.

FORMATION OF OVARIAN CAVITY.—The reproductive cells never lose their identity, they are never transformed into other tissue, and no other cells are ever transformed into reproductive cells.

THE VEGETATION HOUSE AS AN AID IN RESEARCH. BY J. C. ARTHUR.

[ABSTRACT.]

The general construction and purpose of a vegetation house were described, and examples of work performed during the season of 1894 in the one at Purdue university were given in illustration of what may be accomplished when such facilities are available. A vegetation house is essentially a structure to protect growing plants from wind, rain, extremes of cold, and other accidents to which they are subject in the open field. The plants are grown in suitable pots or beds mounted upon trucks, which run on wooden or iron tracks. The plants are only run into the vegetation house when requiring protection, and at other times are left in the open. Although the house is a glass structure, it has no heating arrangements, and is chiefly used during the summer season.

Interesting results obtained by feeding oats and purslane with variable amounts of potash, were explained, and by growing potatoes with a greater or less supply of water, and some other experiments. Photographs accompanied the paper. Some possibilities in the study of the physiology of plants were outlined.

MASS AND MOLECULAR MOTION. BY M. N. ELROD.

THE UNIONIDÆ OF THE OHIO RIVER. BY R. ELLSWORTH CALL.

[ABSTRACT.]

There are now recognized in the freshwater molluscan fauna of North America more than one thousand representatives of the great family of Unionidæ, or fresh-water mussels. A few of these forms, which constitute a peculiarly well-marked division of the family, occur in Mexico and in Central America. Less than a score of species are found in Canada. The rest are peculiar to the United States and, for the greater part, are found east of the Rocky Mountains. More than ninety per cent. of all known forms are from the regions east of the Mississippi and south of the Ohio Rivers. The center of distribution for the described southern forms is the great central plateau region of Middle Kentucky and Tennessee, Western North and South Carolina, and Northern Georgia and Alabama. Within the area as above limited, occur nearly all the species that are known—outside of the great Unionidæ group known as the *complanatus* division. In all the larger streams, and in most of the smaller, throughout all this region, the members of the family flourish in both great numbers of individuals and species. About eighty per cent. of all described North American forms come from this area, and some thirty per cent. of all are from Tennessee, Alabama and Chattahoochee Rivers, and their tributaries.

This singular, but interesting fact, has never yet received the attention it deserves, for geographic distribution, abundance in individuals, and diversity of form are herein correlated clearly with certain geologic factors. For instance, the family is a very ancient one, and dates back to Devonian times at the latest. The region under consideration has constituted a unique land-mass since a very early period in the history of the continent. It has scarce been subjected to glaciation —at least has not since the geologic record exhibited in its country rock began. The very great diversity of form and the great abundance of these modern representatives of a very ancient type, appear plainly to be related in no small degree to these factors.

In investigating in this field, for some twelve years or more past, the species and distribution of these mollusks, attention was necessarily directed to that peculiar Unionine fauna which lies on the northern border of this area. This was rendered necessary, in the first place, by the fact that the Ohio River had itself furnished most of the earlier described types. The literature of the subject reveals some sixty species, distributed unequally among the three Unionine genera, *Unio*, *Anodonta* and *Margaritana*, and shows the forms distributed among these genera in an abundance which has the relation just given, viz.: *Unio* has the greater number of species and *Margaritana* the least.

It was further discovered that as the Ohio River forms of *Unio* are traced over the regions southwards and their geographic and geologic environment becomes changed, that a large number of them sensibly change their external particular characters and grade into forms to this time regarded as peculiar to the region. At once here was opened up the great question of synonymy, with all the consequences which are involved in a wholesale reduction of species.

This study, then, in its final form, will seek to investigate the synonymy—First, of the shells which have been described from the Ohio River. Second, it will select the most marked species of these river mussels and about them, as types, attempt a natural grouping of the Unionine fauna of the valley and the region south. Third, it will attempt to eliminate the synonyms which have been so multiplied by earlier students who were misled by inadequate data or by the older notions of what constituted a species. It will, further, explain in a measure the way in which the different forms assumed by the sexes came to be regarded as species—an unfortunate condition which the *dilettante* of the present day are making worse. It will, fifth, seek to collect, for convenient reference, all figures and descriptions, in the hope that in this way the historic importance of the earlier descriptions may become apparent. These will be arranged chronologically. The Ohio River constitutes historic conchologic ground; from it must begin, as began the old, the new study of the *Unionidæ*.

THE STREPOMATIDÆ OF THE FALLS OF THE OHIO. BY R. ELLSWORTH CALL.

[ABSTRACT.]

The *Strepomatid molluscan fauna* of the Falls of the Ohio is one that is very rich in numbers, but rather poor in species. Including some which will eventually pass into synonymic lists, the total number comprizes but ten species which are distributed among four genera, to wit: *Pleurocera* with three nominal species, *Lithasia* with one species, *Anculosa* with two species, and *Goniobasis* with four species.

The falls mark the line of junction of the Silurian and Devonian strata, which may here be differentiated with very great success and ease. For a distance of some five or six miles the bed of the river is very rocky, with numerous islets of rock, which are always exposed at low water. From one end to the other are innumerable pools in which flourishes a very rich *conferroid flora*, and which furnish a very variable but favorable station for these forms. In numerous places the changes in the current are so marked that at different seasons of the year the

Strepomatid fauna varies with it. For instance, in some places where muddy bottoms, and an abundant flora co-exist, the several members of the genus *Pleurocera* abound. At another, where the bottom is clean rock, or is rock with abundant confervoid vegetation, the genus *Anculosa* occurs in the greatest profusion. At the numerous small falls over the rocky flats, where the water is indifferently swift, and the bottom is either clean or with scanty vegetation, are found great numbers of the four species of *Goniobasis*. At another time in the year, when the stage of the water is changed, a rather different distribution, locally, may be noted. These relations exhibit a certain dependence on local conditions that vary, and, perhaps, serves to explain the very different character of the shell fauna at the same place, at different periods of the year.

The earliest forms that have been described from the Falls are now unknown. They were discovered and studied by the unfortunate Professor Rafinesque, and have long since been merged into synonymy by other students, who were unwilling to allow his claim to original discovery. The attempt lately has been made, with indifferent success, to fix these forms. What result more extensive study of the literature of conchology will finally justify must be left for another time and place. Here it is simply the purpose to place on record the forms which occur, their synonymy as now understood, and a study of those changes in form and habit which manifestly result from the environment of the various representatives of the family.

The species of *Pleurocera* are the following: *Pleurocera canaliculatum*, *P. moniliferum* and *P. elevatum*. There are many specimens which are so difficult of determination, when studied in large series, that one is inclined to the view that forms of extreme variation, but really specifically related, have been given species names which ought to have been not even recognized as varieties. A species monger could erect, by carefully selecting his examples, a dozen or more species from the simple variations in coloration alone, and, strange to relate, this has been done. Thus *Pleurocera canaliculatum* has occurred in abundance with one, two, three and even four revolving purple bands. Many specimens have been secured which are entirely purple, and with no semblance of distinctness in the banding. Hundreds of individuals have been taken that are bright, honey-yellow, and have no tendency to other coloration whatever. Many present the character of channeled whorls, on which the specific name is based, while as many more are found that have plain and well rounded whorls, without any indication of the so-called characteristic grooving. The form called *P. elevatum* itself is a beautiful illustration of the effects of different environment. If taken from swiftly flowing water,

and found attached to rocks, the shells are short and stubby, whorls well thickened and with incrassate aperture. The same shells obtained from pools where the water does not flow at all. and where vegetation flourishes in great abundance, are elongate, thinner in texture, thinner about the aperture, have the lines of growth far apart and well marked. These are the points on which the supposed distinct species have been based, but are thus seen to be but a reflex of the conditions of environment.

The *Goniobases* present the same facts, but since they are often found attached to the faces of vertical rocks, from which they do not migrate very far, there is a very characteristic modification of the aperture which results, evidently, from the effects of gravitation. The final paper will present many facts which tend to this explanation of the different forms of aperture, which, as is well known, determines the real form of the shell.

A few important observations on the animals themselves have been made, but these regard chiefly minor anatomical details and possess little general interest. Enough has been learned, however, to determine that several species, at least, have been based upon the sexes. This difference is seen in the general outline of the female shell, which has always characteristically well-rounded whorls, a condition itself a result of the positions of certain organs within the body of the animal.

Several of the forms found at the Falls of the Ohio are of wide geographic distribution. These limits have been determined and a study made of the shells as expressive of differences in the conditions of the several stations.

The most abundant species of *Anculosa* found at the Falls ranges to the rivers of middle Alabama, and occurs over all the region of east Tennessee, in the larger streams. Coincident with this wide distribution there is a great diversity of form, and thus there has arisen a rather large synonymy, which it is the purpose of this study to establish. Not less than twenty times has *Anculosa prærosa* been described by as many different conchologists who published from scanty material and with the understanding that every stream had its own forms. My own studies in this connection are based upon extensive collecting over all this wide region and on very large quantities of the shells of the several species. The material from the Falls of the Ohio alone, which has passed under observation, comprises something over two bushels of shells. In the quantity one who does not recognize, as Lea did not recognize, the modern notions pertaining to species and the extent to which they respond to geographic factors, might erect forty species with as great propriety as one.

A word or two on the great profligacy of nature in this form of life. During the period of receding waters on the Falls, in the spring and summer, myriads of these mollusks are left in small pools and rills. Later in the season these pools entirely dry up, and the shells, of course, die. It is no exaggeration for me to say that a hundred wagon loads a year, for the past three years that these falls have been under observation, have perished in this way alone, and this has annually occurred for centuries. One is constrained to ask why it is that nature is so profligate of life, and to question whether, after all, the ordinary conception of its sacredness is not one which the facts of nature do not conserve. The fact needs explanation. Certain it is, however, that if these forms reached maturity, and in turn produced their kind in the enormous numbers that the Strepomatids do reproduce, very soon the waters of the river would be dammed by a living, moving mass of animals, which in some situations are so tenacious of life as to have completely occluded large water mains and led to enormous cost to effect their removal.

REPORT OF THE BOTANICAL DIVISION OF THE INDIANA STATE BIOLOGICAL SURVEY FOR 1894.

LUCIEN M. UNDERWOOD, DIRECTOR.

In presenting my second annual report as Director of the Botanical Division of the Biological Survey, it is fair to state that the organization of the survey allows no appropriation for carrying on the work, and whatever has been done by the Director has been in addition to the cares of a laboratory and department of botany. In the present year the Director was necessarily absent from the state during the entire summer and was further prevented from doing as extensive field work during the latter part of the year as was planned, on account of the accumulation of work of other kinds during the summer. It is very desirable that certain explorations be made in some of the less visited portions of the state, and in order to do this some arrangement will have to be made to secure transportation to these regions.

During the spring and fall considerable collections were made in the immediate vicinity of the university (Putnam County) and quite a number of additions were made to the list of last year; the trip to Rochester during the spring meeting of the Academy resulted in several additions to the flora. A trip to Franklin County in November was only partially successful on account of heavy rains. Material has been collected also by Mr. E. W. Olive in Montgomery County, who has made a considerable number of additions to the list of parasitic fungi of the state. Some of my own students have made small collections, notably in Grant, Green and Orange Counties. With further determinations of previously collected materials, together with that collected during the present year, we can add some plants to the previously published list. These plants, with their data, are included in Appendix A to this report. Mr. J. B. Ellis has furnished descriptions of three new species of *Fungi Imperfecti*. A list of new host plants for fungi forms, Appendix B. Notes on the previous report are included in Appendix C.

It is desirable to obtain a complete list of the persons who are willing to collect data and otherwise serve as correspondents to the survey. We ought to have at least one in each county of the state from whom reliable data can be received in regard to the occurrence, relative abundance and present status, of certain plants. If possible, yearly reports as to the appearance of new plants, particularly weeds, should be received. The recent issue of a bulletin on this subject from the State Experiment Station well illustrates the need of a fuller list of correspondents, and as well the immensely practical value of such information

when properly collated and brought into its proper bearings. The fact remains, however, that these correspondents are for the most part only able to render assistance on the higher plants. There are very few persons in the state who have the proper training or who are willing to make the effort to collect the lower plants. Here there is opportunity for those who have charge of courses of instruction in the colleges to render assistance. It would be of immense practical advantage to many of our botanical students to learn how to recognize the lower forms of plant life in the field, and their work in regions which have not yet been visited would add materially to our knowledge of the distribution of these plants in the state.

In order to facilitate the recognition of the lower plants, and in accordance with the preliminary announcement issued last year,* there has been prepared a series of exsiccatæ representing the flora of Indiana. The first fascicle consists of 100 species of parasitic fungi so selected as to illustrate as many as possible of the groups which prey upon the tissues of other plants. These sets are to be distributed as follows:

One set to each of the four colleges of the state in which a department of botany exists, and in which there is a permanent herbarium established.

Three sets to public institutions outside the state, where there are large collections of plants accessible to the botanical student. The herbaria thus selected are (1) the collection of the Missouri Botanic Garden, St. Louis; (2) the Department of Agriculture at Washington; and (3) the Herbarium of Columbia College, New York.

One set to the private herbarium of the Director.

Other sets will be reserved for distribution to other institutions of the state where there is a reasonable certainty that they will be properly preserved and made useful for reference to students; or they will be sent to individuals who contribute an equivalent amount of material representing the lower flora of their respective regions. Some sets have been used by the director for the purpose of exchange with persons outside the state, where this could be done in such a way as to increase his facilities for work.

There are five sets remaining that can be distributed within the state. It is the purpose of the director to issue further sets illustrating other groups if sufficient encouragement is given. The expense of the present issue, including postage, envelopes for the specimens, and labels, to say nothing of the labor of preparation, has been contributed by the director. If it is thought desirable to continue this distribution, it is recommended that the actual outlay of money

* Proc. Indiana Academy of Science, 1893; 16, 1894.

for the above named incidentals be regarded as legitimate expenses of the survey, and be paid for by the Academy. It is also desirable to have the labels in further issues printed in full. This will add greatly to the appearance of the series without any great additional expense.

A list of the plants distributed in this first fascicle is appended. (Appendix D).

The work on the higher flora, as stated in the report of last year, was placed in the hands of Professor Stanley Coulter, who makes a separate report on the progress of his work. A set of blank cards to be used as a working index in preparing the final catalogue was ordered from the Botanical Supply Company, of Cambridge, Mass., and this is the only expense that the Division has asked the Academy to meet during the year. Professor Coulter deserves the thanks of all the botanical workers of the state for the laborious work he has already done, and deserves the support of every man in the state who knows even the commonest plants, in order that the catalogue when published finally shall completely represent the distribution of our higher flora.

It is the intention of the Division to publish from year to year such additions as are made to the flora among the Archegoniates and Thallophytes in order to make a permanent record of their occurrence, for it will be many years before the lower plants of the state will be known with even approximate completeness. It must be remembered that many of the plants belonging to the lower orders are ephemeral in their character, and unless collected in their season disappear and leave no visible trace of their existence. Many of them appear in certain years when the conditions are favorable to their development, and perhaps may not reappear for a succession of years. The past few seasons have been particularly unfavorable for the development of the fleshy fungi, especially those that appear during the midsummer. The same is also true with regard to some that appear in the autumn. As an instance *Phallus Ravenelii* was very abundant in the vicinity of Greencastle during the latter part of 1891, but it has not been seen since. It will thus be seen that the care required in searching for the lower plants is of necessity much greater than in the case of the higher plants, which for the most part are perennial and of constant growth. It will also be seen that the opportunities for bringing to light rare plants is much greater among lower forms. There is scarcely a low, wet piece of woodland where fallen timber is abundant that will not yield a rich harvest of species not yet found in the State. There is scarcely a rocky ravine that will not yield additional bryophytes. There is

scarcely a stagnant pond but that will yield an abundance of algae which have as yet been scarcely touched in this region.*

The great need is for students who have the patience, the perseverance and the fortitude to make a special study of some of these groups that are waiting for the enthusiastic collector.

In conclusion, it is desirable to extend thanks to those who have aided in the prosecution of the work of the survey. Especially would we mention Messrs. Ellis. Peck and Morgan, for the continuance of favors in determinations and for the communication of other material assistance in the work of the survey. To my assistant, Miss Mary E. Wright, for the very laborious work of preparing the labels for the exsiccatæ. And finally to the management of the Vandalia and Big Four Railroads for favors extended to the survey, that have made more extensive field work possible.

APPENDIX A.

LIST OF ADDITIONS TO THE STATE FLORA.

MYXOMYCETES.

ARCYRIA MINOR Schw. Putnam, 5, 1894 (Paul Burlinganius).

HEMIARCYRIA FUNALIS Morgan. Putnam, 10, 1894.

PHYSARUM ATRUM Schw. Tippecanoe, 6, 1893 (Arthur).

PHYSARUM POLYMORPHUM Mont. Grant, 7, 1894 (Mary Wright).

ASCOMYCETES.

DISCOMYCETES.

DASYSCYPHA VIRGINEA (Batsch) Fckl. Putnam, 9, 1893.

MACROPODIA MACROPUS (P.) Fckl. (*Peziza macropus*, P.) Putnam, 5, 1894. (Fred Howe.)

SPHÆRIACEÆ.

CARYOSPORA PUTAMINUM (S.) De Not.
On Peach Stones, Putnam, 5, 1893.

DIATRYPELLA CEPHALANTHI (S.) Sacc.

*One of the great drawbacks in the study of the algæ is the lack of proper references. The director is pleased to announce that he had secured a set of Rabenhorst's *Die Algen Europas*, (including over 2,500 specimens of algæ exsiccatæ): and shall be glad to make them useful to students who wish to consult them. These, with the two series of American exsiccatæ issued during the present year, sets of which are now in the herbarium of the director, give fairly good opportunity to compare our local forms.

On Cephalanthus occidentalis, Putnam, 12, 1892.

EUTYPELLA PLATANI (S.) Sacc.

On Sycamore, Putnam, 5, 1893.

HYPOXYLON PETERSII B. and C. Putnam, 11, 1894.

HYPOXYLON SASSAFRAS (S.) Berk.

On Lindera, Putnam, 12, 1894.

NUMMULARIA REPANDA Fr. Putnam, 7, 1893.

SPHAERELLA THALICTRI E. and E.

On Thalictrum dioicum, Montgomery, —, 1894 (Olive).

TREMATO PERTUSA (P.) Fckl. Owen, 5, 1893.

DOTHIDIACEÆ.

DOTHIDEA COLLECTA (Schw.) E. & E.

On Osage orange. Putnam, 5, 1892.

DOTHIDEA LINDERÆ Ger.

On Lindera Benzoin. Putnam, 10, 1893.

FUNGI IMPERFECTI.

SPHÆROPSIDEÆ.

CONIOTHYRIUM CONCENTRICUM Desm.

On Yucca (cult.) Montgomery, 5, 1894 (Olive).

PHYLLOSTICTA CHENOPODII West.

On Chenopodium album. Montgomery, 1894 (Olive).

PHYLLOSTICTA DESMODII E. & E.

On Desmodium rotundifolium. Montgomery, 1894 (Olive).

PHYLLOSTICTA LABRUSCÆ Thuem.

On Vitis labrusca. Montgomery, 1894 (Olive.)

PHYLLOSTICTA MACROSPORA E. & E.

On Liriodendron tulipifera. Wabash, 8. 1892 (Miller).

PHYLLOSTICTA PODOPHYLLI Wint.

On Podophyllum peltatum. Montgomery, 1894 (Olive).

PHYLLOSTICTA ROSÆ Desm.

On Rosa setigera. Montgomery 7, 1894 (Olive).

PHYLLOSTICTA SOLITARIS E. & E., n. sp.

On Pirus coronaria. Montgomery, 10, 1893.

PHYLLOSTICTA SMILACIS E. & M.

On Smilax rotundifolia. Montgomery, 9, 1893 (Olive).

SEPTORIA AGRIMONIÆ Boum.

On Agrimonia Eupatoria, Montgomery, 6, 1894 (Olive).

SEPTORIA CALYSTEGIÆ West.

On Convolvulus sepium, Putnam, 6, 1894.

SEPTORIA CERASTII Rob. and Desm.

On Cerastium sp., Putnam, 5, 1894.

SEPTORIA CONSOCIA Pk.

On Polygala senega, Montgomery, O., 1894 (Olive).

SEPTORIA CRYPTOTÆNIÆ E. and Rau.

On Cryptotænia Canadensis, Montgomery, 1894 (Olive).

SEPTORIA ERIGERONTIS Pk.

On Erigeron annuus, Montgomery, 1894 (Olive).

On Erigeron Philadelphicus, Montgomery, 1894 (Olive).

SEPTORIA HEUCHERÆ Pass.

On Heuchera Americana, Montgomery, 4, 1894 (Olive).

SEPTORIA PIRICOLA Desm.

On Pirus communis, Tippecanoe, 9, 1892 (Arthur); Putnam, 10, 1892; 7, 1893; Montgomery, 9, 1894 (Olive).

? SEPTORIA PHLOGIS Sacc. and Speg.

On Phlox divaricata, Montgomery, 1894 (Olive).

SEPTORIA PTELEÆ E. and E.

On Ptelea trifoliata, Montgomery, 9, 1894 (Olive).

SEPTORIA RECURVATA E. and Halst.

On Trillium erectum, Montgomery, 1894 (Olive).

SEPTORIA SAMBUCINA Pk.

On Sambucus Canadensis, Montgomery, 1894 (Olive).

SEPTORIA SCROPHULARIÆ Pk.

On Scrophularia nodosa, Putnam, 10, 1893; Montgomery, 1894 (Olive).

SEPTORIA STAPHYSAGRIÆ Wint.

On Delphinium tricorne, Vigo, 5, 1893.

SEPTORIA URTICÆ Desm.

On Laportea Canadensis, Montgomery, 1894 (Olive).

VERMICULARIA LILIACEARUM Ursd. Fulton, 10, 1893.

VERMICULARIA VIOLÆ E. and E., n. sp.*

On Viola cucullata, Montgomery, 1894 (Olive).

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* VERMICULARIA VIOLÆ, E. and E. On leaves of *Viola cucullata*, Canada (Dearness), Indiana (E. W. Olive). Epiphyllous or subglobose or irregularly shaped. White spots 2 to 3 mm. in diameter. Perithecia punctiform, clothed with straight, black, obscurely septate bristles 75-150x3½-4 μ. Sporules fusoid, hyaline, slightly curved, 15-20x3 μ.

HYPHOMYCETES.

CERCOSPORA AMPHAKODES E. and H.

On Phlox divaricata, Montgomery, 1894 (Olive).

CERCOSPORA ARMORACIÆ Sacc.

On Nasturtium armoracia, Montgomery, 9, 1893 (Olive).

CERCOSPORA CAULOPHYLLI Pk.

On Caulophyllum thalictroides, Montgomery, 1894 (Olive).

CERCOSPORA CLEOMIS Ell. & Halst.

On Polanisia graveolens, Montgomery, 9, 1894 (Olive).

CERCOSPORA NASTURTII Pass.

On Nasturtium officinale, Montgomery, 10, 1893 (Olive).

CERCOSPORA POLYGONORUM Cke.

On Polygonum hydropiper, Putnam, 10, 1893.

On P. Muhlenbergii, Montgomery, 1894 (Olive).

CERCOSPORA SORDIDA Sacc.

On Tecoma radicans, Putnam, 9, 1893, Montgomery, 10, 1893.

DIDYMARIA FULVA E. and E., n. sp.*

On Dioscorea villosa, Montgomery, 1894 (Olive).

EPICOCCUM NEGLECTUM Desm.

On Sanguinaria canadensis, Montgomery, 6, 1894 (Olive).

MONILIA SITOPHILA (Mont.) Sacc.

On corn cobs. Putnam, 4, 1895 (Melia Ellis).

OIDIUM MEGALOSPORUM Berk. Vermillion 9, 1889 (Arthur).

PHOMA GLANDICOLA Desm.

On acorns. Vigo, 5, 1893.

RAMULARIA VARIABILIS Fckl.

On Verbascum thapsus. Montgomery, 1894 (Olive).

SEPTONEMA SPILOMEUM Berk. Vermillion, 9, 1889 (Arthur).

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*DIDYMARIA FULVA E. and E. On leaves of *Dioscorea villosa*, Crawfordsville, Ind., July, 1894 (E. W. Olive). Hypophyllous forming small yellow patches, made up of closely crowded tufts of fusoid or narrow ovate, uniseptate, hyaline conidia 12-22 (mostly 15-20) x 3-5 μ., straight or slightly curved, and often constricted at the septum. Hyphæ short, hardly distinguishable from the conidia. The shorter conidia are also the broader ones, and are mostly obtuse at one end, while the longer ones are generally acute at both ends. Differs from the usual type of *Didymaria* in its yellow color and short, almost obsolete basidia.

MELANCONIEÆ.

CYLINDROSPORIUM OFFICINALE E. & E., n. sp.*
On Saponaria officinalis. Montgomery, 5, 1894 (Olive).

BASIDIOMYCETES.

USTILAGINEÆ.

ENTYLOMA SANICULÆ Pk.
On Sanicula, Putnam, 5, 1893.
SCHIZONELLA MELANOGRAMMA (DC.) Schrt.
On Carex. sp., Fulton, 5, 1894.
UROCYSTIS CEPULÆ Frost.
On onions in market, Putnam, 12, 1893.

UREDINEÆ.

ÆCIDIUM COMPOSITARUM Mart.
On Eupatorium perfoliatum, Montgomery, 1894 (Olive).
On Lactuca Canadensis, Montgomery, 1894 (Olive).
ÆCIDIUM ERIGERONATUM Schw.
On Erigeron annuus, Montgomery, 6, 1894 (Olive).
ÆCIDIUM NAPÆÆ Arth. and Holw.
On Napæa dioica, Tippecanoe, 6, 1889 (Arthur).
ÆCIDIUM THALICTRI-FLAVI (DC).
On Anemonella thalictroides, Montgomery, 1894 (Olive).
PUCCINIA FUSCA (Relh.), Wint.
On Anemone nemorosa, Fulton, 5, 1894
PUCCINIA OBTECTA Pk.
On Scirpus sp., Marshall, 10, 1893.
On Scirpus lacustris, Montgomery, 9, 1893, (Olive).
PUCCINIA PHYSOSTEGIÆ Pk. and Clinton.

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* CYLINDROSPORIUM OFFICINALE E. & E.
On leaves of *Saponaria officinalis*. *Crawfordsville*, Ind., May, 1894 (E. W. Olive). Spots numerous. Small (1-1½ mm.), dark brown, with a purplish shaded border, sometimes confluent. Acervuli epiphyllous, numerous, subcircinate. Sporules filiform, slightly curved, continuous, 30—40x1¼—1½ μ, issuing in white cirrhi.
Septoria Saponariæ is on subindefinite, yellowish spots, and has true perithecia with sporules 40—50x3½—4½ μ, and is a very different thing from this.
Cylindrosporium Saponariæ, Roum., is on large, grayish green spots, and has conidia 10—40x3—5 μ.

On Physostegia Virginiana, Marshall. 10, 1893.

Uromyces rudbeckii Arth. and Holw.

On Rudbeckia laciniata. Montgomery, 1894 (Olive).

Tremellineæ.

Guepinia elegans B. and C. Putnam, 12, 1894; Marion, 1, 1895 (Boatright).

HYMENOMYCETES.

Thelephoreæ.

Corticium ochroleucum spumeum B. and Rav. Putnam, 10, 1893.

Exobasidium vaccinii (Fckl.) Woron.

On Vaccinium sp., Brown, 5, 1893.

Hymenochæte cinerasces S. Putnam, 12, 1891.

Hymenochæte rubiginosa Schrad. Putnam, 10, 1891; 4, 1892; 10, 1893.

Stereum subpileatum B. and C. Montgomery, 4, 1892.

Hydnei.

Grandinia tuberculata B. and C. Putnam, 10, 1893.

Hydnum membranaceum Bull. Putnam, 11, 1894 (R. Norton).

Radulum orbiculare Fr. Putnam 10, 1893.

Polyporineæ.

Polyporus biformis Fr. Putnam, 10, 1892.

Polyporus brumalis Fr. Putnam, 12, 1894.

Polyporus chioneus Fr. Putnam, 10, 1893.

Polyporus cinereus S. Vigo, 10, 1893.

Polyporus epileucus Fr. Putnam, 7, 1894.

Polyporus ferruginosus Schrad. Vigo, 10, 1893.

Polyporus galactinus Berk. Putnam, 10, 1894.

Polyporus lucidus Fr. Putnam, 10, 1894; Vigo, 9, 1894 (Blatchley); Greene, 8, 1894 (Myrtle Hays).

Polyporus nidulans Fr. Putnam, 10, 1891; 10, 1893.

Polyporus purpureus Fr. Putnam, 10, 1893.

Polyporus reniformis Morgan. Putnam, 4, 1895.

Polyporus salicinus Fr. Putnam, 12, 1891; 12, 1894.

Polyporus salmonicolor B. and C. Putnam 12, 1894.

Polyporus subacidus Pk. Putnam, 4, 1893.

POLYPORUS SUPINUS Fr. Vermillion, 4, 1893 (Arthur).
POLYPORUS RAPORARIUS Pers. Putnam, 12. 1894.
POLYPORUS VULGARIS Fr. Putnam, 10, 1892; 4, 1893.
TRAMETES SEPIUM Berk. Putnam, 10, 1891; 10, 1893.

AGARICINEÆ.

CLANDOPUS NIDULANS Pers. Putnam, 12, 1894.
CREPIDOTUS HÆRENS Pk. Putnam, 6, 1893.
LEPIOTA FRIESII Lasch. Putnam, 10, 1893.
LEPIOTA RUBROTINCTA Pk. Putnam, 10, 1893.
PLEUROTUS APPLICATUS Batsch. Putnam, 12, 1891.
PLEUROTUS SAPIDUS Kalchbr. Putnam, 11, 1894
STROPHARIA STERCORARIA Fr. Putnam, 10, 1891.
LENTINUS TIGRINUS Bull. Vigo, 10, 1893.
LENTINUS VULPINUS Fr. Putnam, 12, 1894.

GASTROMYCETES.

LYCOPERDACEÆ.

GEASTER MINIMUS S. Monroe, 12, 1894 (R. Norton).
LYCOPERDON CURTISII Berk. Tippecanoe, 10, 1894 (Arthur).
LYCOPERDON ECHINATUM P. Vermillion, 8, 1889 (Arthur).

BRYOPHYTA.

RICCIACEÆ.

RICCIOCARPUS NATANS (L.) Corda. Montgomery, 3, 1895 (Olive).

MARCHANTIACEÆ.

LUNULARIA CRUCIATA (L.) Dumort. In green houses, Tippecanoe, 3, 1895.

APPENDIX B.

ADDITIONAL LIST OF HOST PLANTS OF FUNGI, 1894.

CACALIA RENIFORMIS (Septoria cacaliæ). Montgomery, 1894 (Olive).
CARDAMINE RHOMBOIDEA (Albugo candidas). Montgomery, 1894 (Olive).
CRATAEGUS CRUS-GALLI (Rœstelia lacerata). Montgomery, 1894 (Olive).
HELIANTHUS STRUMOSUS (Erysiphe cichoracearum). Montgomery, 1894 (Olive).
LACTUCA SCARIOLA (Septoria lactucæ). Montgomery, 1894 (Olive).

POLYGONUM HYDROPIPEROIDES (Septoria polygonorum). Montgomery, 1894 (Olive).

POLYGONUM MUHLENBERGII (Septoria polygonorum). Montgomery, 1894 (Olive).

RIBES FLORIDUM (Æcidium grossulariæ). Montgomery, 1894 (Olive).

SOLIDAGO ARGUTA (Æcidium asterum). Montgomery, 1894 (Olive).

TRIODIA CUPRÆA (Puccinia emaculata). Montgomery, 1894 (Olive).

VITIS RIPARIA (Uncinula necator). Montgomery, 1894 (Olive).

APPENDIX C.

NOTES ON THE SPECIES REPORTED PREVIOUSLY.

1. MUTINUS CANINUS (p. 63). The species reported under this name is *M. Ravenelii* B. & C. according to Mr. Morgan.
2. PUCCINIA INDUSIATA Dietel & Holway *ined* (p. 54). This species has since been described under the name of *P. nigrovelata* Ellis & Tracy (Bull. Torr. Bot. Club, 22:60, F. 1895), which latter name being the first published will have priority. This is one of the species distributed.
3. DOTHIDELLA ULMI (p. 42) should be *Dothidella ulmea* (Schw.) E. & E.
4. RHYTISMA PRINI (p. 33) is *R. Ilicis-Canadensis* S., according to Mr. Ellis. This is correctly named in the distribution.
5. The EXOASCUS (p. 34) reported on *Ostrya Virginica* is *Taphrina Virginica* Sadebeck & Seymour, according to Prof. Atkinson.

APPENDIX D.

LIST OF PARASITIC FUNGI DISTRIBUTED BY THE INDIANA BIOLOGICAL SURVEY. DECEMBER, 1894. SERIES 1. No. 1—100.

1. *Ustilago anomala* J. Kuntze.
2. *Ustilago avenæ* (P.) Jensen.
3. *Ustilago panici-glauci* (Wallr.) W.
4. *Ustilago tritici* (P.) Jensen.
5. *Ustilago Rabenhorstiana* Kuehn.
6. *Ustilago syntherismæ* (S.) Pk.
7. *Ustilago zeæ-mays* (DC.) Wint.
8. *Entyloma physalidis* (K. and C.) Wint.
9. *Tilletia striæformis* (Westd.) Wint.
10. *Schizonella melanogramma* (DC.) Schrt.
11. *Puccinia menthæ* P.

12. *Puccinia obtecta* Pk.
13. *Puccinia physostegiæ* P. and C.
14. *Puccinia graminis* P.
15. *Puccinia podophylli* S.
16. *Puccinia xanthii* S.
17. *Puccinia galii* (P.) Wint.
18. *Puccinia violæ* (Schum.) DC.
19. *Puccinia interstitialis* (Scht.) Tranzs.
20. *Puccinia lobeliæ* Ger.
21. *Puccinia convolvuli* (P.) Cast.
22. *Puccinia caricis* (Schum.) Reb.
23. *Puccinia maydis* Carr.
24. *Puccinia tanaceti* DC.
25. *Puccinia Dayi* Clinton.
26. *Puccinia polygoni-amphibii* P.
27. *Puccinia indusiata* Diet. and Hol.
28. *Puccinia circææ* P.
29. *Puccinia emaculata* S.
30. *Puccinia vernoniæ* S.
31. *Puccinia lateripes* B. and Rav.
32. *Puccinia angustata* Pk.
33. *Puccinia andropogi* S.
34. *Uromyces terebinthi* (DC.) Wint.
35. *Uromyces hedysari-paniculati* (S) Farl.
36. *Uromyces Howei* Pk.
37. *Uromyces junci* Tul.
38. *Uromyces trifolii* (A. and S.) Wint.
39. *Uromyces lespedezæ* (S.) Pk.
40. *Uromyces appendiculata* (P.) Lev.
41. *Uromyces polygoni* (P.) Fckl.
42. *Uromyces hyperici* (S.) Curt.
43. *Uromyces euphorbiæ* C. and P.
44. *Uropyxis amorphæ* (Curt.) Schrt.
45. *Gymnosporangium globosum* Farl.
46. *Gymnosporangium macropus* Link.
47. *Phragmidium fragariæ* (DC.) Rossm.
48. *Phragmidium subcorticium* (Schr.) Wint.
49. *Melampsora salicina* Lev.
50. *Melampsora populina* (Jacq.) Lev.
51. *Cæoma agrimoniæ* S.
52. *Uredo iridis* DC.
53. *Uredo polypodii* (P.) DC.
54. *Coleosporium sonchi-arvensis* (P.) Lev.
55. *Æcidium ranunculi* S.
56. *Æcidium sambuci* S.
57. *Æcidium pustulatum* Curt.
58. *Æcidium grossulariæ* DC.
59. *Æcidium euphorbiæ* S.
60. *Ræstelia lacerata* (Sow.) Fr.
61. *Uncinula parvula* C. & P.
62. *Uncinula salicis* (DC.) Wint.
63. *Uncinula geniculata* Ger.
64. *Uncinula macrospora* Pk.
65. *Uncinula circinata* C. & P.
66. *Uncinula necator* (S.) Burr.
67. *Uncinula flexuosa* Pk.
68. *Uncinula Clintonii* Pk.
69. *Sphærotheca castagnei* Lev.
70. *Sphærotheca phytoptophila* K. & S.
71. *Sphærotheca humuli* (DC.) Burr.
72. *Erysiphe galeopsidis* DC.
73. *Erysiphe communis* (Wallr.) Fr.
74. *Erysiphe liriodendri* S.
75. *Podosphæra biuncinata* C. & P.
76. *Podosphæra oxyacanthæ* (DC.) By.
77. *Microsphæra grossulariæ* (Wallr.) Lev.
78. *Microsphæra erineophila* Pk.
79. *Microsphæra Ravenelii* Berk.
80. *Microsphæra symphoricarpi* Howe.

81. *Microsphæra Russellii* Clinton.
82. *Microsphæra quercina* (S.) Burr.
83. *Microsphæra elevata* Burr.
84. *Microsphæra semitosta* B. & C.
85. *Microsphæra alni* (DC.) Wint.
86. *Phyllactinia suffulta* (Reb.) Sacc.
87. *Leptostroma hypophyllum* B. & Rav.
88. *Rhytisma andromedæ* (P.) Fr.
89. *Rhytisma ilicis-Canadensis* S.
90. *Rhytisma acerinum* (P.) Fr.
91. *Cercospora effusa* (B. & C.) E. & E.
92. *Cercospora polygonorum* Cke.
93. *Septoria cacaliæ* E. & K.
94. *Septoria scrophulariæ* Pk.
95. *Septoria piricola* Desm.
96. *Phyllosticta asiminæ* E. & K.
97. *Phyllosticta paviæ* Desm.
98. *Albugo candidus* (P.) Kuntze.
99. *Albugo amaranti* (S.) Kuntze.
100. *Plasmopara geranii* (Pk.) B. & DeT.

GREENCASTLE, IND., December 25, 1894.

FLORA OF HAMILTON AND MARION COUNTIES, INDIANA.

BY GUY WILSON.

This list is only preliminary, several of the families, notably Gramineæ and Cyperaceæ, being very incomplete.

The Salicaceæ have not been very satisfactorily studied.

Plants which are not represented in my Herbarium but can be collected are marked thus: ½.

If doubtful if they can be collected, thus: *

All Fungi, Musci, Hepaticæ and Lichenes were collected in Hamilton County.

Other names followed by Hamilton County or Marion County were found only in that county. Otherwise they are common to both counties.

GREENCASTLE, IND., May 23, 1895.

LICHENES.

Parmelia caperata (L.) Ach. Common.
  saxatilis (L.) Fr. Rock. Common.
Ramalina calicaria (L.) Timber. Common.
Sticta amplissima (Scop.) Mass. Timber. Common.
  pulmonaria (L.) Ach. Timber. Common.
Usnea barbata (L.) Fr. Timber. Common.

Fungi.

Claviceps purpurea (Fr.) Tul. On Rye. Common.
Xylaria polymorpha (Pers.) Grev. Rare.
Phyllachora graminis (Pers.) Fckl. On Cinna arundinacea. Common.
Ustilago Zea-mays (D. C.) Wint. On Zea mays. Common.
Puccinia indusita Deitl & Holway. On Cyperus strigosus. Common.
    interstitialis (Schl.) Tranzschel. On all sp. of Rubus. Very common.
Dædalea confragosa Bolt. Rare.
Lenzites betulina (L.) Fr. Common.
Polyporus sulphureus (Bull.) Fr. Common.
    applanatus Willd. Common.
Trametes cinibarina (Jacq.) Fr. Common.

Hepaticæ.

Riccia fluitans L. Ponds. Rare.
Conocephalus conicus (L.) Durmort. Rare.
Marchantia polymorpha L. Rare.

Musci.

Anomodon rostratus (Hedw.) Schrimp. Common.
Clamacium Americanum Brid. Rare.
Drummondia clavellata Hook. Common.
Funaria hygrometrica (L.) Sibth. Common.
Hypnum cupressiforme L. Common.
    serpens L. Common.
Mnium cuspidatum Hedw. Rare.
Physcomitrum turbinatum (Michx.) Brid. Common.
Polytrichium Ohioense Ren. and Cardot. Common.
Tetraphis pellucida Hedw. Common.

Ophioglossaceæ.

Botrychium ternatum Sw. Rare. Hamilton County.
    Virginianum (L.) Sw. Rare. Hamilton County.

Filices.

Adiantum pedatum L. Common.
Pteris aquilina L. Very rare. Hamilton County.
Asplenium acrostichoides Sw. Common. Hamilton County.
    angustifolium Michx. Common. Hamilton County.

Phegopteris hexagonoptera (Michx.) Fee. Common.
Dryopteris acrostichoides (Michx.) Kuntze. Common.
 spinulosa intermedia (Muhl.) Underw. Common. Hamilton County.
 Thelypteris (L.) A. Gray. Very common. Hamilton County.
Cystopteris bulbifera (L.) Bernh. Very rare. Marion County.
 fragilis (L.) Bernh. Very common. H.
Onoclea sensibilis L. Very common.
Osmunda regalis L. Very rare. Hamilton County.

All plants of this and the preceding order are known as ferns.

EQUISETACEÆ.

Equisetum arvense L. Very common.
 hyemale L. Common. Hamilton County.

CONIFERÆ.

Thuja occidentalis S. Very rare. Hamilton County.
Juniperus Virginiana L. Common.

TYPHACEÆ.

Typha latifolia L. Common.

SPARGANIACEÆ.

Sparganium eurycarpum Engelm. in A. Gray. Common. Hamilton County.

ALISMACEÆ.

Alisma Plantago-aquatica L. Common.
Sagitaria latifolia Willd. Common.
 latifolia pubescens (Muhl.) J. G. Smith. Common.

GRAMINEÆ.

Panicum capillare L. Common.
 Crus-galli L. Common.
 sanguinale L. Very common.
Chamæraphis glauca (L.) Kuntze. Very common.
 viridis (L.) Porter. Common.
Phleum pratense L. Very common.
Alopecurus geniculatus fulvus (J. E. Smith) Scribn. Rare. Hamilton County.
Cinna arundinacea L. Common.

§ *Agrostis alba vulgaris* (With.) Thurb. Rare.

Eragrostis Eragrostis (L.) Karst. Common.

Major (Host.) Common.

Frankii (Steud.) Common. Hamilton County.

Dactylis glomerata L. Common.

§ *Poa Pratensis* L. Very common.

§ *Bromus secalinus* L. Very common.

Hystrix Hystrix (L.) Millsp. Common.

CYPERACEÆ.

Cyperus strigosus L. Common.

Eleocharis ovata (Roth.) Roem. and Schult. Common. Hamilton County.

Scirpus Americanus Pers. Rare. Hamilton County.

atrovirens Muhl. Common.

cyperinus (L.) Kunth. Common.

lacustris L. Common.

Carex platyphylla Carey. Common.

ARACEÆ.

§ *Acorus Calamus* L. Rare.

Spathyema fœtida (L.) Raf. Common.

Arisæma Dracontium (L.) Schott. Common. Hamilton County.

tryphyllum (L.) Torr. Common.

COMMELINACEÆ.

Tradescantia Virginiana (L.) Common.

JUNCACEÆ.

Juncus tenuis Willd. Very common.

LILIACEÆ.

Veratrum Woodii Robbins. Very rare. Hamilton County.

Uvularia grandiflora J. E. Smith. Common.

§ *Allium Canadense* L. Common. Hamilton County.

§ *tricoccum* Ait. Rare. Hamilton County.

* *Lilium Philadelphicum* L. Very rare. Hamilton County.

Erythronium albidum Nutt. Rare.

Americanum Ker. Common.

Camassia Fraseri (A. Gray) Torr. Common. Hamilton County.

? *Asparagus officinalis* L. Not common.

Vagnera racemosa (L.) Morong. Common.

stellata (L.) Morong. Very rare. Hamilton County.

Polygonatum biflorum (Walt.) Ell. Very common.

biflorum commutatum (R. & S.) Morong. Very common.

Trillium erectum L. Common. Hamilton County.

recurvatum Beck. Very common.

SMILACEÆ.

Smilax herbacea L. Common.

rotundifolia L. Very common.

DISCOREACEÆ.

Dioscorea villosa L. Common.

IRIDACEÆ.

Iris versicolor L. Common.

Sisyrinchium Bermudiana L. Common. Hamilton County.

ORCHIDACEÆ.

* *Cypripedium hirsutum* Mill. Very rare. Hamilton County.

reginæ Walt. Very rare. Hamilton County.

Orchis spectabilis L. Very rare. Hamilton County.

Pogonia trianthophora (Sw.) B. S. P. Very rare. Hamilton County.

? *Aplectrum spicatum* (Walt.) B. S. P. Rare. Hamilton County.

SAURURACEÆ.

Saururus cernuus L. Common.

JUGLANDACEÆ.

Juglans cinerea L. Common.

nigra L. Common.

Hicoria alba (L.) Britton. Common.

glabra (Mill.) Britton. Rare.

microcarpa (Nutt.) Britton. Common.

minima (Marsh.) Britton. Common.

ovata (Mill.) Britton. Common.

* *Pecan* (Marsh.) Britton. Very rare. Hamilton County.

SALICACEÆ.

‡ *Populus alba* L. Beginning to escape from cultivation.

monilifera Ait. Common.

tremuloides Michx. Common.

Salix nigra Marsh.? Specimen so named in J. E. McMullan's collection of Woods from Hamilton County.

discolor Muhl. ? Common. Hamilton County.

discolor eriocephala (Michx.) Anders. ? Rare. Hamilton County.

fragilis L. ? Common.

humilis Marsh. ? Common. Hamilton County.

lucida Muhl. ? Rare. Hamilton County.

purpurea L. ? Very rare. Hamilton County.

rostrata Richards. ? Common. Hamilton County.

sericea Marsh. ? Common. Hamilton County.

BETULACEÆ.

Carpinus Caroliniana Walt. Common.

Ostrya Virginiana (Muhl.) Willd. Common.

Corylus Americana Walt. Common.

FAGACEÆ.

Fagus atropunicea (Marsh.) Sudw. Common.

Quercus alba L. Common.

macrocarpa Michx.

macrocarpa oliveformis (Michx. f.) A. Gray. Very rare. Hamilton County.

Muhlenbergii Engelm. Common.

minor (Marsh.) Sarg. Rare. Hamilton County.

‡ *Prinus* L. Very rare. Hamilton County.

rubra L. Common.

ULMACEÆ.

Ulmus Americana L. Common.

pubescens Walt. Common.

racemosa Thomas. Rare. ? Hamilton County.

Celtis occidentalis L. Common.

Moraceæ.

Morus rubra L. Common.
§ *Toxylon pomiferum* Raf. Very rare. Hamilton County.
Humulus Lupulus L. Common. Hamilton County.
Cannabis sativa L. Common.

Urticaceæ.

Urtica gracilis Ait. Very Common.
Urticastrum divaricatum (L.) Kuntze. Very common.
Adicea pumila (L.) Raf. Common. Hamilton County.
Bœhmeria cylindrica (L.) Willd. Common. Hamilton County.

Aristolochiaceæ.

Asarum Canadense L. Very common.

Polygonaceæ.

Rumex Acetosella L. Common.
crispus L. Common.
sanguineus L. Common.
verticillatus L. Common.
Polygonum dumetorum L. Very common.
emersum (Michx.) Britton. Very rare. Hamilton Co.
Hydropiper L. Common.
hydropiperoides Michx. Common.
incarnatum Ell. Common.
orientale L. Very rare. Hamilton County.
punctatum Ell. Common.
sagittatum L. Common.
aviculare L. Common.
erectum L. Common.
Fagopyrum Fagopyrum (L.) Gaertn. Scarce.

Chenopodiaceæ.

Chenopodium album L. Very common.
Botrys L. Rare.

AMARANTHACEÆ.

Amaranthus blitoides S. Wats. Common.
hybridus L. Common.
retroflexus L. Common.
spinosus L. Rare.

PHYTOLACCACEÆ.

Phytolacca decandra L. Common.

AIZOACEÆ.

Mullugo verticillata L. Very common.

PORTULACACEÆ.

Claytonia Virginica Michx. Common.
Portulaca oleracea L. Very common.

CARYOPHYLLACEÆ.

§ *Agrostemma Githago* L. Very common.
Silene alba Muhl. Rare.
§ *antirrhina* L. Common.
stellata (L.) Ait. f. Common.
regia Sims. Very rare. Hamilton County.
Virginica L. Common.
Saponaria officinalis L. Common.
Alsine longifolia (Muhl.) Britton. Rare. Hamilton County.
media L. Common.
pubera (Michx.) Britton. Common.
Cerastium longipedunculatum Muhl. Common.
vulgatum L. Common.

NYMPHÆACEÆ.

Nymphæa advena Soland. Rare. Hamilton County.

MAGNOLIACEÆ.

Liriodendron Tulipifera L. Common.

ANONACEÆ.

Asimina triloba (L.) Dunal. Common.

Ranunculaceæ.

Hydastris Canadensis L. Very rare. Hamilton County.
Caltha palustris L. Common. Hamilton County.
Isopyrum biternatum (Raf.) T. and G. Common.
Actæa alba (L.) Mill. Common.
Delphinium tricorne Michx. Rare. Hamilton County.
Anemone Canadensis L. Common. Hamilton County.
Hepatica acuta (Pursh.) Britton. Very common.
Syndesmon thalictrioides (L.) Hoffmg. Very common.
Clematis Viorna L. Rare. Hamilton County.
Virginiana L. Common.
Ranunculus abortivus L. Very common.
delphinifolius Torr. Rare. Hamilton County.
recurvatus Poir. in Lam. Common.
septentrionalis Poir. Common.
? *Batrachium divaricatum* (Schrank) Wimm. Common. Hamilton County.
Thalictrum dioicum L. Rare. Hamilton County.
polygamum Muhl. Common.

Berberidaceæ.

Podophyllum peltatum L. Very common.
Caulophyllum thalictroides (L.) Michx. Rare. Hamilton County.

Menispermaceæ.

Menispermum Canadense L. Common.

Lauraceæ.

Sassafras Sassafras (L.) Karst. Common.
Benzoin Benzoin (L.) Coulter. Common.

Papaveraceæ.

Sanguinaria Canadensis L. Common.
Stylophorum diphyllum (Michx.) Nutt. Common.
Bicuculla Canadensis (Goldie) Millsp. Common.
Cucullaria (L.) Millsp. Common.

CRUCIFERAE.

Lepidium Virginicum L. Very common.
Sisymbrium officinale (L.) Scop. Very common.
Sinapis alba L. Rare. Hamilton County.
Brassica nigra (L.) Koch. Very common.
Sinapistrum Boiss. Common. ?
Barbarea Barbarea (L.) MacM. Common. Hamilton County.
Iodanthus pinnatifidus (Michx.) Prantl. Common. Hamilton County.
? *Roripa Armoracia* (L.) A. S. Hitchcock. Common.
Nasturtium (L.) Rusby. Rare.
palustris (L.) Bess. Common.
Cardamine bulbosa (Schreb.) B. S. P. Common.
Douglassii (Torr.) Britton. Common.
hirsuta L. Common. Hamilton County.
Dentaria lacinata Muhl. Common.
? *Bursa Bursa-Pastoris* (L.) Weber. Very common.
Arabis dentata T. & G. Rare. Hamilton County.
laevigata (Muhl.) Poir. Common. Hamilton County.

CRASSULACEAE.

Sedum Telephium L. Escaped from cultivation. Rare. Hamilton County.
ternatum Michx. Common.
Penthorum sedoides L. Common. Hamilton County.

SAXIFRAGACEAE.

Saxifraga Pennsylvanica L. Common. Hamilton County.
Mitella diphylla L. Common.
Hydrangea arborescens L. Common.
Ribes Cynosbati L. Common.
floridum L. Her. Common.

PLATANACEAE.

Platanus occidentalis L. Common.

ROSACEÆ.

Opulaster opulifolius (L.) Kuntze. Rare.

Pyrus coronaria L. Common.

Malus L. Common.

* *Amelanchier Canadensis* (L.) Medic. ? Very rare. Hamilton County.

Crataegus coccinea L. Common.

molis (T. and G.) Scheele. Rare. Hamilton County.

punctata Jacq. Common.

tomentosa L. Specimen so named in J. E. McMullan's collection of woods from Hamilton County.

§ *Rubus Baileyanus* Britton. Common.

* *Canadensis* L. Rare.

occidentalis L. Common.

§ *villosus* Ait. Common.

Fragaria vesca L. Common.

Potentilla Canadensis L. Common.

§ *Geum Canadense* Jacq. Common.

radiatum Michx. Common.

vernum (Raf.) T. and G. Common.

Ulmaria rubra Hill. Very rare. Marion County.

Agrimonia parviflora Soland. Common.

stricta Michx. Common.

Rosa Carolina L. Common.

§ *lucida* Ehrh. Common.

rubiginosa L. Not common. Hamilton County.

Prunus Americana Marsh. Common.

serotina Ehrh. Common.

LEGUMINOSÆ.

Cercis Canadensis L. Common.

Cassia Chamaecrista L. Rare.

Marylandica L. Common.

Gleditschia triacanthos L. Common.

§ *Gymnocladus dioicus* (L.) Koch. Common.

§ *Melilotus alba* Lam. Common.

Trifolium hybridum L. Rare. Hamilton County.

pratense L. Very common.

repens L. Very common.

Meibomia canescens (L.) Kuntze. Common.

Dillenii (Darl.) Kuntze. Common.

grandiflora (Walt.) Kuntze. Very common.

Lathyrus palustris L. Very rare. Hamilton County..

Apios Apios (L.) MacM. Rare. Hamilton County.

Phaseolus helvolus L. Rare. Hamilton County.

polystachyus (L.) B. S. P. Common.

GERANACEÆ.

Geranium maculatum L. Common.

OXALIDACEÆ.

Oxalis stricta L. Common.

RUTACEÆ.

Zanthoxylum Americanum Mill. Common.

Ptelea trifoliata L. Common. Hamilton County.

SIMARUBACEÆ.

Ailanthus glandulosa Desf. Very rare. Marion County.

EUPHORBIACEÆ.

Euphorbia corollata L. Rare. Hamilton County.

Cyparissias L. Common.

LIMNANTHACEÆ.

Flœrkea proserpinacoides Willd. Common. Hamilton County.

maculata L. Common.

marginata Pursh. Escaped to streets of Noblesville and Carmel. Rare.

nutans Lag. Common.

§ *Acalypha Virginica* L. Common.

ANACARDIACEÆ.

§ *Rhus glabra* L. Common.

radicans L. Common.

§ *Vernix* L. Common. Hamilton County.

AQUIFOLIACEÆ.

Ilex verticillata (L.) A. Gray. Common. Hamilton County.

CELASTRACEÆ.

? *Euonymus atropurpureus* Jacq. Common.
obovatus Nutt. Common.
Celastrus scandens L. Common.

STAPHYLEACEÆ.

Staphylea trifolia L. Common.

ACERACEÆ.

Acer Negundo L. Common.
? *nigrum* Michx. f. Common.
rubrum L. Common.
saccharinum L. Common.
Saccharum Marsh. Common.

HIPPOCASTANACEÆ.

Æsculus glabra Willd. Common.

BALSAMINACEÆ.

Impatiens aurea Muhl. Common.
biflora Walt. Common.

VITACEÆ.

? *Vitis cordifolia* Michx. Common.
? *Labrusca* L. Common.
? *vulpina* L. Common.
? *Parthenocissus quinquefolia* (L.) Planch in D. C. Common.

TILIACEÆ.

Tilia Americana L. Common.

MALVACEÆ.

Abutilon Abutilon (L.) Rusby. Very common.
Althæa-rosea Cav. Escaped from cultivation in some places.
Malva rotundifolia L. Very common.
Sida spinosa L. Very common.
? *Hibiscus Trionum* L. Rare.

HYPERICACEÆ.

Hypericum ellipticum Hook. Common.
mutilum L. Common. Hamilton County.

VIOLACEÆ.

Viola obliqua Hill. Very common.

obliqua alba (Y. and N.). Very rare. Hamilton County.

? *palmata* L. Common.

pubescens Ait. Common.

striata Ait.

Solea concolor (Forst.) Gingins. Very rare. Hamilton County.

THYMELÆACEÆ.

* *Dirca palustris* L. Said to occur in the northern part of Hamilton County.

LYTHRACEÆ.

Lythrum alatum Pursh. Very rare. Hamilton County.

Decodon verticillatus (L.) Ell. Very rare. Hamilton County.

ONAGRACEÆ.

Epilobium palustre L. Common.

Onagra biennis (L.) Scop. Very common.

Gaura biennis L. Common.

Michauxii Spach. Common.

Circæa Lutetiana L. Rare. Petals sometimes red.

ARALIACEÆ.

Aralia racemosa L. Rare. Hamilton County.

* *Panax quinquefolium* L. Very rare. Hamilton County.

UMBELLIFERÆ.

Daucus Carota L. Very common.

Oxypolis rigidus (L.) Britton. Very common.

Heracleum lanatum Michx. Common. Hamilton County.

Pastinaca sativa L. Very common.

Thaspium trifoliatum (L.) Britton. Common.

trifoliatum aureum (Nutt.) Britton. Common. Hamilton County.

Sanicula Canadensis L. Common. Hamilton County.

Chærophyllum procumbens (L.) Crantz. Common. Hamilton County.

Osmorrhiza longistylis (Torr.) D. C. Common. Hamilton County.

Sium cicutæfolium J. F. Gmel. Common. Hamilton County.

Erigenia bulbosa (Michx.) Nutt. Common.

CORNACEÆ.

Cornus alternifolia L. Common. Hamilton County.
    ♄ *candidissima* Marsh. Common.
    circinata L. Her. Common.
    florida L. Common.
    * *stolonifera* Michx. Rare. Hamilton County.
Nyssa aquatica L. Rare.

MONOTROPACEÆ.

Monotropa uniflora L. Rare. Hamilton County.
Hypopitys Hypopitys (L.) Small. Very rare. Hamilton County.

PRIMULACEÆ.

Samolus floribundus H. B. K. Common. Hamilton County.
Steironema ciliatum (L.) Baudo. Common. Hamilton County.
Naumburgia thyrsiflora (L.) Duby. Rare. Hamilton County.

OLEACEÆ.

Fraxinus Americana L. Common.
    ♄ *nigra* Marsh. Common.
    ♄ *quadrangulata* Michx. Common.

GENTIANACEÆ.

Gentiana Andrewsii Griseb. Rare. Hamilton County. ?

APOCYNACEÆ.

Vinca minor L. Becoming common.
Apocynum androsæmifolium L. Rare. Hamilton County.
    ♄ *cannabinum* L. Common.

ASCLEPIDACEÆ.

Asclepias exalta (L.) Muhl. Rare. Hamilton County.
    incarnata L. Common.
    ♄ *Syriaca* L. Very common.
    tuberosa L. Rare. Hamilton County.

CONVOLVULACEÆ.

Ipomœa hederacea Jacq. Rare. Hamilton County.
lacunosa L. Common.
purpurea (L.) Roth. Very common.
Convolvulus repens L. Common.
Sepium L. Common.

CUSCUTACEÆ.

Cuscuta glomerata Choisy. Common.

POLEMONIACEÆ.

Phlox divaricata L. Very common.
maculata L. Rare. Hamilton County.
paniculata L. Common.
Polemonium reptans L. Common.

HYDROPHYLLACEÆ.

Hydrophyllum appendiculatum Michx. Common.
macrophyllum Nutt. Common.
Phacelia bipinatifida Michx. Common.
Purshii Buckl. Very rare. Hamilton County.

BORAGINACEÆ.

Cynoglossum officinale L. Common.
Lappula Lappula (L.) Karst. Very common.
Mertensia Virginica (L.) D. C. Rare. Hamilton County.
Lithospermum arvense L. Common.
Onosmodium Carolinianum (Lam.) A. D. C. Very rare. Hamilton County.

VERBENACEÆ.

Verbena stricta Vent. Common.
urticæfolia L. Common.
Lippia lanceolata Michx. Common.
Phryma Leptostachya L. Common.

LABIATÆ.

Collinsonia Canadensis L. Common.

Perilla frutescens Nankinensis (Lour.) Britton. Escaped from cultivation.

Mentha piperita L. Common.

Lycopus Europæus L. Common. Hamilton County.

Virginicus L. Common. Hamilton County.

Koellia pilosa (Nutt.) Britton. Rare.

Virginiana (L.) Britton Rare. Hamilton County.

Hedeoma pulegioides (L.) Pers. Very common.

Monarda fistulosa L. Common.

Blephilia ciliata (L.) Raf.? Very rare. Hamilton County.

Vleckia nepetoides (L.) Raf. Common.

Nepeta Cataria L. Very common.

Glecoma hederacea L. Very common.

Scutellaria incana Muhl. Common.

lateriflora L. Common.

nervosa Pursh. Very rare. Marion County.

Prunella vulgaris L. Common.

Physotegia Virginiana (L.) Benth. Common.

Marrubium vulgare L. Rare.

Stachys aspera Michx. Common.

palustris L. Common.

Leonurus Cardiaca L. Very common.

SOLANACEÆ.

Physalodes physalodes (L.) Britton. Rare.

Physalis Philadelphica Lam. Common.

pubescens L. Common.

viscosa L. Common.

Solanum Carolinense L. Common.

nigrum L. Common.

rostratum Dunal. Very rare. Marion County.

Datura Stramonium L. Very common.

Tatula L. Very common.

SCROPHULARIACEÆ.

Verbascum Blattaria L. Rare. Hamilton County.

  ? *Thapsus* L. Very common.

? *Linaria Linaria* (L.) Karst. Common.

Collinsia verna Nutt. Rare. Hamilton County.

Scrophularia Marylandica L. Common.

Chelone glabra L. Common.

  obliqua L. Very rare. Hamilton County.

Pentstemon Digitalis (Sweet.) Nutt. Common.

  hirsutus (L.) Willd. Very rare. Hamilton County.

Mimulus alatus Soland in Ait. Common.

Gratiola Virginiana L. Common.

Veronica arvensis L. Very common.

  officinalis L. Common. Hamilton County.

  peregrina L. Very common.

  serpyllifolia L. Very common.

Leptandra Virginica (L.) Nutt. Very rare. Hamilton County.

Afzelia macrophylla (Nutt.) Kuntze. Common. Hamilton County.

Gerardia Skinneriana Wood. Rare. Hamilton County.

Pedicularis lanceolata Michx. Very rare. Marion County.

OROBANCHACEÆ.

Conopholis Americana (L. f.) Wallr. Very rare. Hamilton County.

Epiphegus Virginiana (L.) Bart. Common.

BIGNONIACEÆ.

Tecoma radicans (L.) DC. Common.

ACANTHACEÆ.

Ruellia ciliosa Pursh. Common.

Dianthera Americana L. Very common.

PLANTAGINACEÆ.

Plantago lanceolata L. Rare.

  major L. Very common.

RUBIACEÆ.

Houstonia purpurea L. Very rare. Marion County.
Cephalanthus occidentalis L. Common.
Gallium Aparine L. Common.
asprellum Michx. Rare. Hamilton County.
circæzans Michx. Common.
trifidum L. Common.

CAPRIFOLIACEÆ.

Sambucus Canadensis L. Common.
Viburnum acerifolium L. Very rare. Hamilton County.
prunifolium L. Common.
Triosteum perfoliatum L. Common. Hamilton County.

VALERIANACEÆ.

Valeriana pauciflora Michx. Common.
Valerianella chenopodiifolia (Pursh.) D C. Common.

DIPSACEÆ.

Dipsacus sylvestris Huds. Very common.

CUCURBITACEÆ.

Micrampelis lobata (Michx.) Greene. Common.
Sicyos angulatus L. Common.

CAMPANULACEÆ.

Campanula Americana L. Common.
Legouzia perfoliata (L.) Britton. Common.
Lobelia cardinalis L. Common.
inflata L. Common.
syphilitica L. Common.
½ *puberula* Michx. Common.

COMPOSITÆ.

Vernonia fasciculata Michx. Very common.

Eupatorium ageratoides L. Common.

altissimum L. Very rare. Marion County.

Cœlestinum L. Common.

perfoliatum L. Common.

purpureum L. Common.

½ *maculatum* L. Common.

Coleosanthus grandiflorus (Hook.) Kuntze. Very rare. Hamilton County.

½ *Kuhnia eupatorioides*. Common.

Solidago cæsia L. Common.

flexicaulis L. Common.

Riddellii Frank. Very rare. Hamilton County.

rigida L. ? Common.

speciosa Nutt. ? Common.

Aster. Several species which are uncertain.

½ *Erigeron annuus* (L.) Pers. Common.

Canadensis L. Very common.

ramosus (Walt.) B. S. P. Very common.

Antennaria margaritacea (L.) Hook. Common.

plantaginifolia (L.) Richards. Rare. Hamilton County.

Inula Helenium L. Common.

½ *Silphium perfoliatum* L. Rare. Hamilton County.

terebinthaceum L. Rare. Hamilton County.

Ambrosia artemisiæfolia L. Very common.

trifida L. Very common.

trifida integrifolia (Muhl.) T. and G. Very rare. Hamilton County.

½ *Xanthium Canadense* Mill. Very common.

strumarium L. Very common.

Rudbeckia hirta L. Very rare. Hamilton County.

laciniata L. Very rare. Hamilton County.

triloba L. Common.

Lepachys pinnata (Vent.) T. and G. Very rare. Hamilton County.

½ *Helianthus annuus* L. Common.

strumosus L. Common.

tuberosus L. Common.

Coreopsis tripteris L. Common.

Bidens bipinnata L. Very common.

cernua L. Common.

connata (L.) Muhl. Very common.

frondosa L. Very common.

trichosperma (Michx.) Britton. Common.

Helenium autumnale L. Common.

Achillea Millefolium L. Common.

Anthemis Cotula L. Very common.

Chrysanthemum Leucanthemum L. Rare. Hamilton County.

? *Tanacetum vulgare* L. Common.

Senecio aureus L. Common. Hamilton County.

Cacalia reniformis Muhl. Rare. Hamilton County.

Arctium Lappa L. Very common.

† *Carduus altissimus* L. ? Not seen in flower. Common. Hamilton County.

arvensis (L.) Robs. Rare. Hamilton County.

lanceolatus L. Very common.

muticus (Michx.) Pers. Common.

Cichoriaceæ.

Adopogon Dandelion (L.) Kuntze. Very rare. Hamilton County.

Taraxacum Taraxacum (L.) Karst. Very common.

Lactuca Canadensis L. Very common.

Scariola L. Very common.

Sonchus asper (L.) All. Common

INDEX.

INDEX.

PROCEEDINGS

...OF THE...

Indiana Academy of Science

∴ 1895 ∴

Editor, - C. A. WALDO.
Associate Editors, - J. C. ARTHUR,
W. A. NOYES,
C. H. EIGENMANN,
A. W. DUFF,
V. F. MARSTERS,
A. W. BUTLER,
W. S. BLATCHLEY.

INDIANAPOLIS, IND.
FEBRUARY, 1896.

IVERSITY BIOLOGICAL STATION.

Hydrographic Map of

INDIANAPOLIS:
WM. B. BURFORD, PRINTER,
1896.

TABLE OF CONTENTS.

An Act to provide for the publication of the reports and papers of the Indiana Academy of Science.

[Approved March 11, 1895.]

Preamble.

Whereas, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State, and,

Whereas, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form, and,

Whereas, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement, therefore,

Publication of the reports of the Indiana Academy of Science.

Section 1. *Be it enacted by the General Assembly of the State of Indiana*, That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

Editing reports.

Sec. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits, to be determined by the concurrent action of the editors and the Commissioners of Public

Number of printed reports.

Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894. Proviso.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture. Disposition of reports.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage. Emergency.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

[Approved March 5, 1891.]

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That it shall be unlawful for any person to kill any wild bird other than a game bird or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird. Birds.

SEC. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers. surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act. Game Birds.

Penalty. SEC. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days.

Permits. SEC. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act.

Permits to Science. SEC. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege, and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed any bird or taken the nests or eggs of any bird for any other purpose than that named in this section, and shall further be subject for each offense to the penalties provided in this act.

Bond.

Bond forfeited.

Two years. SEC. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of prey. SEC. 7. The English or European house sparrow (passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed. SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency. SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

INDIANA ACADEMY OF SCIENCE.

(A Statement Made to the General Assembly, in 1895, of Its Work and Purposes.)

The Indiana Academy of Science has published during the last three years three volumes of proceedings. The first volume appeared in '92. It included many of the papers in full or in abstract that were presented at the previous Christmas meeting of the Society, together with titles and authors of all other papers presented before the Academy since its organization in 1885. Of all the titles appearing in this volume, many of them upon topics of vital importance, not over five per cent. were discussed in full in the publication. All the rest of this valuable literature has been scattered and lost or rendered practicably inaccessible.

The volumes appearing in '93 and '94 give in full or in abstract most of the important papers presented in each case at the previous holiday meeting, while the volume appearing in the summer of '94 is enriched by the reports of a large corps of voluntary and unpaid but thoroughly trained workers, who have undertaken and are energetically pushing a systematic biological survey of the State. But the expense attending these publications has been too great for private enterprise and the treasury of the Academy. Unless the State now takes hold of the matter they must cease for a time, at least, and a serious break in the proceedings must occur. This would be a lamentable check upon the progress of science in the State. At this crisis the State is asked to join hands with the Academy only in so far as to establish and preserve the work to which the latter is dedicated. It is our purpose here to set forth in detail, but briefly, some of the reasons why the State should make this compact. These reasons fall under two general heads: The Workers and Their Work.

By publishing the proceedings of the Academy the State secures, without further compensation, the services of over a hundred trained experts working in fields specially chosen and agreeable, spending a large portion of their time upon new problems whose solution is of vital importance to the development of our Commonwealth. These workers have been trained in the best schools, home and

foreign, and bring to their investigations zeal, enthusiasm, skill, patience and common sense. For the results of their work they seek no other remuneration than the honor that comes from the willing and loving recognition of their labors by their friends, neighbors and fellow-citizens, to whose highest and best interests their lives are consecrated. These trained experts, who constitute the best authority in the State upon their several subjects, will act without compensation with the legislative body of Indiana just as the National Academy acts in conjunction with Congress; will freely advise with the legislators when asked upon scientific subjects, and give proper direction to scientific investigations undertaken by the Legislature as a basis for wholesome and logical laws.

To the work already done the publications of the Academy give but an imperfect witness. Certain it is that interest in these proceedings, incomplete as they are, has gone out far beyond the confines of our own States and has been extensively awakened even in transatlantic countries. The Academy has helped to train some of the foremost scientists of our day. When it expresses an opinion upon a scientific subject it is listened to with respect, even by such distinguished scientists as have been drawn in large numbers to our nation's capital.

It will be here attempted to set forth the scope and aims of the Indiana Academy in the barest outlines. The outline itself must be imperfect at best, but we hope this synopsis will show how closely it is identified in all of its ramifications with public progress. Without pretending to exhaust the subject, we will arrange under six heads what we have to say upon the character of the work undertaken by the Academy and the reasons why this work should be fostered by the State to the extent of proper publication and dissemination of its results. The six heads are: Educational Services, Development of Natural Resources, Industrial Assistance, Economical Effects, Contributions to the Reputation of the State and Recognition Accorded to This Kind of Work in Other States.

We may mention six ways in which the work of the Academy strengthens the educational forces of the State: 1. Through its meetings and publications the Academy gives direction and enthusiasm to the study of the sciences throughout Indiana. Scientific instruction is no longer taken up in a half-hearted, perfunctory way, but is instinct with life and energy. 2. It transforms teachers into life-long investigators. The best science teachers are those most under its influence. 3. It fosters and develops workers apart from and outside of the schools. All have observed the tonic effects on a community of a single bright, active mind. With every person thus endowed the Academy joins hands and helps him make a general uplift of his own locality in just such a way as university extension operates. 4. It brings together for conference teachers who are opening up

lines of work in their several localities and enables them to plan and distribute original work in the wisest manner. 5. It fosters a spirit of home effort which makes the student of science everywhere practically familiar with home surroundings and alive to the possibilities of home fields and forests. 6. It classifies and arranges in a systematic way the whole plant and animal life of the State, making accessible at small expense to everybody the most important information otherwise scattered through an expensive library.

Without going into details, it is only necessary to call attention to the fact that everywhere the Academy is a powerful auxillary in developing the mineral, vegetable and animal resources of the State.

We may consider the industrial activity of the Academy under three heads: Its efforts in behalf of agriculture, of mines and minerals, of manufactures. It aids agriculture by studying and eradicating injurious weeds; by investigating insect life and showing what insects are beneficial, which injurious, and devising means for fostering the former and exterminating the latter; by studying parasitic fungi, their habits, effects, control; by the investigation and adaptation of soils; by studying birds and animals in their relation to agriculture.

It aids mines and mineral industries—by the study of coal, gas, oil, clays, sands, road materials, gravels, building stones, etc.; by application of physics, chemistry and mechanics to mine work; by the application of scientific knowledge of existing conditions, to the end that money should not be wasted in wild-catting and other useless operations.

It aids manufacturing industries—by investigating the physical and chemical properties of wood and iron, by perfecting accurate and economical methods of manufacture and testing; by stimulating and laying the foundations for the development of inventions which shall convert a given amount of power into the maximum amount of useful product; by investigating and devising economical methods of developing and distributing power; by preventing the expenditure of money upon unscientific and useless inventions.

We may group the general economical services of the Academy under three heads:

1. It strives to increase the possibilities of existing properties—by improving the soils; by the study and culture of fish; by developing new soil products, such as the sugar beet, or by investigating the conditions under which they flourish; by utilizing neglected food materials, such as mushrooms, etc.; by discovering practical and beneficial uses for waste products; by studying the uses of woods, clays, etc. in the arts and manufactures; by studying the medicinal properties of

plants; by studying the properties of plants injurious or fatal to man or beast, as the stagger-weed.

2. It strives to increase the happiness, safety and productive capacity of society by investigating food adulteration, drainage, water supply, sanitary questions; by investigating the effects of mineral and vegetable poisons upon man and animals; by studying the diseases of animals; by investigating general economical and social problems.

3. It studies the question of the protection of forms of life beneficial to man, such as forests, native birds, game and fishes.

In general, we may remark, the reputation of a State is a matter of pecuniary as well as sentimental importance. While it is true that the work of the Academy is widely known and its worth acknowledged, while the same is true for other educational forces in the State, yet when all is said, we must confess that we occupy too low a position in the estimation of the scientific world, lower we believe, than our merit as a State deserves. On the other hand, if the State Legislature should cordially recognize the work being done, should encourage investigation along all lines by the method here suggested, as it can at so slight an expense, that act alone of enlightened and far-seeing policy would greatly improve our reputation; it would tend to give tone and character to the State; it would make the strong workers within its borders more patriotic; they would not be so ready when opportunity offers to change their residence to some more appreciative community; it would do much to attract from without first-class ability to assist in making Indiana in every respect what her fertility and natural resources intended she should be—a leader among the States of the Union.

New York, Connecticut, Wisconsin, Illinois, Minnesota, Iowa, Kansas and the National Government, together with the foremost foreign States and nations, are more or less committed to the policy advocated. Its results in Indiana can not be different from those achieved elsewhere. Its adoption can only inure to the great and lasting benefit of Indiana and all her people.

The amount annually needed to publish in a proper manner, illustrate and distribute the proceedings of the Society will not exceed $2,000. The Academy does not ask a direct appropriation of money, but an annual publication of its proceedings.

As shown by its constitution, the objects of the Academy "shall be scientific research and the diffusion of knowledge concerning the various departments of science."

The membership is limited only by the following clause:

"Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership." The membership now numbers 146, of whom 25, known as Fellows, are supposed in a special manner to represent the Academy in its relations to the general public.

In order that the general character of the Academy may be clearly understood, the list of Fellows with their addresses is appended:

Daniel Kirkwood, Riverside, Cal.; J. C. Arthur, Lafayette; P. S. Baker, Greencastle; W. S. Blatchley, Indianapolis; J. C. Branner, Palo Alto, Cal.; A. W. Butler, Brookville; J. L. Campbell, Crawfordsville; John M. Coulter, Lake Forest, Ill.; Stanley Coulter, Lafayette; H. T. Eddy, Minneapolis, Minn.; C. H. Eigenmann, Bloomington; W. F. M. Goss, Lafayette; Thomas Gray, Terre Haute; O. P. Hay, Chicago, Ill.; H. A. Huston, Lafayette; J. P. D. John, Greencastle; D. S. Jordon, Palo Alto, Cal.; V. F. Marsters, Bloomington; T. C. Mendenhall, Worcester, Mass.; D. M. Mottier, Bloomington; W. W. Norman, Austin, Texas; W. A. Noyes, Terre Haute; W. P. Shannon, Greensburg; Alex. Smith, Chicago, Ill.; W. E. Stone, Lafayette; M. B. Thomas, Crawfordsville; L. M. Underwood, Greencastle; T. C. Van Nuys, Bloomington; C. A. Waldo, Greencastle.

OFFICERS, 1895-96.

President,
STANLEY COULTER.

Vice-President,
THOMAS GRAY.

Secretary,
JOHN S. WRIGHT.

Assistant Secretary,
A. J. BIGNEY.

Treasurer,
W. P. SHANNON.

EXECUTIVE COMMITTEE.

Stanley Coulter,
Thomas Gray,
John S. Wright,
A. J. Bigney,
W. P. Shannon,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter.
David S. Jordan.

CURATORS.

BOTANY..................................J. C. Arthur.
ICHTHYOLOGY..........................C. H. Eigenmann.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY......................Amos W. Butler.
ENTOMOLOGY..........................W. S. Blatchley.

COMMITTEES, 1895-96.

PROGRAM.

C. A. Waldo, A. J. Bigney,

MEMBERSHIP.

C. H. Eigenmann, George A. Talbert, G. W. Benton.

NOMINATIONS.

W. A. Noyes, W. E. Stone, W. S. Blatchley.

AUDITING.

W. E. Stone.

STATE LIBRARY.

C. A. Waldo, W. A. Noyes, A. W. Butler,
A. W. Duff, J. S. Wright.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

J. C. Arthur, J. M. Coulter, J. S. Wright.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, Ph. Kirsch.

EDITOR.

C. A. Waldo.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, V. F. Marsters, J. C. Arthur.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, A. W. Butler, C. H. Eigenmann.

GRANTING PERMITS FOR COLLECTING BIRDS.

A. W. Butler, C. H. Eigenmann, W. P. Shannon.

DISTRIBUTION OF THE PROCEEDINGS.

A. W. Butler, W. A. Noyes, C. A. Waldo.
C. H. Eigenmann, V. F. Marsters, J. S. Wright.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Treasurer.
1885–6	David S. Jordan.	Amos W. Butler.	....	O. P. Jenkins.
1886–7	John M. Coulter.	Amos W. Butler.	....	O. P. Jenkins.
1887–8	J. P. D. John.	Amos W. Butler.	....	O. P. Jenkins.
1888–9	John C. Branner.	Amos W. Butler.	....	O. P. Jenkins.
1889–90	T. C. Mendenhall.	Amos W. Butler.	....	O. P. Jenkins.
1890–1	O. P. Hay.	Amos W. Butler.	....	O. P. Jenkins.
1891–2	J. L. Campbell.	Amos W. Butler.	....	C. A. Waldo.
1892–3	J. C. Arthur.	Amos W. Butler.	Stanley Coulter. W. W. Norman.	C. A. Waldo.
1893–4	W. A. Noyes.	C. A. Waldo.	W. W. Norman.	W. P. Shannon.
1894–5	A. W. Butler.	John S. Wright.	A. J. Bigney.	W. P. Shannon.
1895–6	Stanley Coulter.	John S. Wright.	A. J. Bigney.	W. P. Shannon.

CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members

but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a president, vice-president, secretary, assistant secretary, and treasurer, who shall perform the duties usually pertaining to their respective offices, and in addition, with the ex-presidents of the Academy, shall constitute an executive committee. The president shall, at each annual meeting, appoint two members to be a committee which shall prepare the programmes and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the executive committee. There shall also be a summer meeting at such time and place as may be decided upon by the executive committee. Other meetings may be called at the discretion of the executive committee. The past presidents, together with the officers and executive committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The president shall deliver a public address on the evening of one of the days of the meeting at the expiration of his term of office.

3. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.

5. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

6. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

FELLOWS.

J. C. Arthur.................................Lafayette.
P. S. Baker.................................Greencastle.
W. S. Blatchley.................................Indianapolis.
J. C. Branner.................................Palo Alto, Cal.
Wm. Lowe Bryan.................................Bloomington.
A. W. Butler.................................Brookville.
R. E. Call.................................Cincinnati, O.
J. L. Campbell.................................Crawfordsville.
John M. Coulter.................................Lake Forest, Ill.
Stanley Coulter.................................Lafayette.
D. W. Dennis.................................Richmond.
C. H. Eigenmann.................................Bloomington.
Katherine E. Golden.................................Lafayette.
W. F. M. Goss.................................Lafayette.
Thos. Gray.................................Terre Haute.
A. S. Hathaway.................................Terre Haute.
O. P. Hay.................................Chicago, Ill.
H. A. Huston.................................Lafayette.
J. P. D. John.................................Greencastle.
D. S. Jordan.................................Stanford University, Cal.
V. F. Marsters.................................Bloomington.
C. L. Mees.................................Terre Haute.
T. C. Mendenhall.................................Hoboken, N. J.
D. M. Mottier.................................Bloomington.
W. A. Noyes.................................Terre Haute.
J. T. Scovell.................................Terre Haute.
W. P. Shannon.................................Greensburg.
Alex. Smith.................................Chicago, Ill.

W. E. Stone.......................................Lafayette.
M. B. Thomas.....................................Crawfordsville.
L. M. Underwood ....Auburn, Ala.
T. C. Van Nuys...................................Bloomington.
C. A. Waldo ....Lafayette.
F. M. Webster ....Wooster, O.
H. W. Wiley.......................................Washington, D. C.
J. S. Wright.......................................Indianapolis.

NON-RESIDENT MEMBERS.

D. H. Campbell ....Stanford University, Cal.
B. W. Evermann ....Washington, D. C.
Charles H. Gilbert ....Stanford University, Cal.
C. W. Green ....Stanford University, Cal.
C. W. Hargitt.....................................Syracuse, N. Y.
Edward Hughes...................................Stockton, Cal.
O. P. Jenkins.....................................Stanford University, Cal.
J. S. Kingsley.....................................Tufts College, Mass.
Alfred Springer ....Cincinnati, O.
Robert B. Warder ....Washington, D. C.

ACTIVE MEMBERS.

R. J. Aley ....Bloomington
Timothy H. Ball ....Crown Point.
H. H. Ballard.....................................Terre Haute.
C. L Barnes ....Indianapolis.
George W. Benton ....Indianapolis.
Andrew J. Bigney ....Moore's Hill.
J. A. Bergstrom ....Bloomington.
A. W. Bitting.....................................Lafayette.
Alexander Black ....Greencastle.
M. A. Brannon ....Ft. Wayne.
Charles C. Brown ....Indianapolis.
H. L. Bruner ....Irvington.
Severance Burrage ....Lafayette.

J. B. Burris....................................Cloverdale.
Noble C. Butler ....Indianapolis.
J. T. Campbell ....Rockville.
E. J. Chansler ....Bicknell.
Fred. M. Chamberlain ....Bloomington.
J. Fred. Clearwaters............................Indianola, Ill.
H. J. Clements..................................Washington.
U. O. Cox ....Mankato, Min.
M. E. Crowell ....Indianapolis.
Glenn Culbertson ....Hanover.
Will Cumback ....Greensburg.
Alida M. Cunningham ....Kirkpatrick.
H. S. Cunningham ....Indianapolis.
George L. Curtiss ....Columbus.
B. M. Davis.....................................Irvington.
J. P. Dolan ....Syracuse.
Chas. R. Dryer..................................Terre Haute.
A. Wilmer Duff..................................Lafayette.
Joseph Eastman ....Indianapolis.
E. G. Eberhardt.................................Indianapolis.
M. N. Elrod ....Hartsville.
F. L. Emory ....Ithaca, N. Y.
Percy Norton Evans ....Lafayette.
Samuel G. Evans.................................Evansville.
E. M. Fisher....................................Lake Forrest, Ill.
J. J. Flather...................................Lafayette.
A. L. Foley.....................................Bloomington.
Robert G. Gillum ....Terre Haute.
J. R. Francis ....Indianapolis.
Austin Funk ....Bloomington.
J. B. Garner ....Crawfordsville.
U. F. Glick.....................................Newbern.
Michael J. Golden...............................Lafayette.
W. E. Goldsborough..............................Lafayette.
*C. F. Goodwin ....Brookville.
*S. S. Gorby ....Indianapolis.
Vernon Gould....................................Rochester.

*Deceased.

J. C. Gregg	Brazil.
E. H. Heacock	Leadville, Colo.
Chas. A. Helvie	Chicago.
Wm. Perry Hay	Irvington.
Franklin W. Hays	Indianapolis.
Flora Herr	Bloomington.
Robert Hessler	Logansport.
T. E. Hibben	Indianapolis.
J. W. Hubbard	Bloomington.
Thomas M. Iden	Irvington.
Alex. Jameson	Indianapolis.
A. E. Jessup	Carmel.
Sylvester Johnson	Irvington.
W. B. Johnson	Franklin.
Chancey Juday	Bloomington.
E. M. Kindle	Bloomington.
J. G. Kingsbury	Irvington.
Ph. Kirsch	Columbia City.
Charles T. Knipp	Bloomington.
Thomas Large	Rensselaer.
Daniel Layman	Indianapolis.
V. H. Lockwood	Indianapolis.
Robert E. Lyons	Bloomington.
Herbert W. McBride	Indianapolis.
Robert Wesley McBride	Indianapolis.
Kate McCarthy	Wabash.
Rousseau McClellan	Indianapolis.
D. T. McDougal	Minneapolis, Minn.
J. W. Marsee	Indianapolis.
G. W. Martin	Indianapolis.
Franklin S. Miller	Brookville.
W. J. Moenkhaus	Bloomington.
G. T. Moore	Crawfordsville.
Joseph Moore	Richmond.
J. P. Naylor	Greencastle.
Charles E. Newlin	Indianapolis.
John F. Newsom	Elizabethtown.
E. W. Olive	Frankfort.

J. H. Oliver .... Indianapolis.
D. A. Owen .... Franklin.
George J. Peirce .... Bloomington.
W. H. Peirce .... Indianapolis.
Elwood Pleas .... Dunrieth.
A. H. Purdue .... Chicago, Ill.
Ryland Ratliff .... Fairmount.
H. G. Reddick .... Bloomington.
Bessie C. Ridgley .... South Bend.
D. C. Ridgley .... Delphi.
Curtis A. Rinson .... Bloomington.
George L. Roberts .... Greensburg
L. J. Rettger .... Terre Haute.
Adolph Rodgers .... Newcastle.
John F. Schnaible .... Lafayette.
C. E. Schafer .... Huntington.
Claude Siebenthal .... Bloomington.
G. W. Sloan .... Indianapolis.
Richard A Smart .... Lafayette.
Harold B. Smith .... Lafayette.
Theo. W. Smith .... Indianapolis.
F. P. Stauffer .... Logansport.
M. C. Stevens .... Lafayette.
H. M. Stoops .... Brookville.
Joseph Swain .... Bloomington.
William Stewart .... Lafayette.
Geo. A. Talbert .... Laporte.
Frank B. Taylor .... Fort Wayne.
Erastus Test .... Lafayette.
F. C. Test .... Washington, D. C.
Wm. M. Thrasher .... Irvington.
A. L. Treadwell .... Oxford, Ohio.
A. B. Ulrey .... Bloomington.
W. B. Van Gorder .... Knightstown.
J. H. Voris .... Bloomington.
Ernest Walker .... New Albany.
F. A. Walker .... Anderson.
W. P. Wallheiser .... Bedford.

W. O. Wallace	Wabash.
Wm. M. Whitten	South Bend.
J. R. Wiest	Richmond.
W. L. Wood	Covington.
A. J. Woolman	Duluth, Minn.
P. A. Yoder	Bloomington.
A. C. Yoder	Bloomington.
O. B. Zell	Clinton.

Fellows	36
Non-resident members	10
Active members	134
Total	180

. . . . PROGRAM . . .

OF THE

ELEVENTH ANNUAL MEETING

OF THE

Indiana Academy of Science,

STATE HOUSE, INDIANAPOLIS,

December 27 and 28, 1895.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

A. W. BUTLER	President	D. S. JORDAN,	T. C. MENDENHALL,
STANLEY COULTER	Vice-President	J. M. COULTER,	O. P. HAY,
JOHN S. WRIGHT	Secretary	J. P. D. JOHN,	J. L. CAMPBELL,
A. J. BIGNEY	Assistant Secretary	J. C. BRANNER,	J. C. ARTHUR,
W P. SHANNON	Treasurer	W. A. NOYES,	Ex-Presidents.

The Sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture.

PROGRAM COMMITTEE.

P. S. BAKER.....................Greencastle | GEO. W. BENTON.............Indianapolis

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GENERAL PROGRAM.

Thursday, December 26.

Meeting of Executive Committee at Denison House .... 8 p. m.

Friday, December 27.

General Session .... 9 a. m. to 12 m.
Sectional Meetings .... 2 p. m. to 5 p. m.
Address by President A. W. Butler .... 7 p. m.

Saturday, December 28.

General Session, followed by Sectional Meetings .... 9 a. m. to 12 m.
General Session .... 2 p. m. to 4 p. m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

MR. A. W. BUTLER,

At 7 o'clock Friday evening.

Subject—"Indiana: A Century of Changes in the Aspects of Nature."

AT THE SAME HOUR, BY REQUEST,

MR. W. W. PFRIMMER

Will read a new poem. Subject—"The Naturalist."

The address has been placed at this early hour in order that other engagements for the usual hours of evening entertainment may not keep the members of the Academy and their friends from being present.

The following papers will be read in the order in which they appear on the program, except that certain portions of the program will be presented *pari passu* in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no statement of time was sent with the papers, they have been uniformly assigned ten minutes. Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By order of the Academy no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL SUBJECTS.

1. Unconscious mental cerebration, 5 m. . . . . C. E. Newlin
2. Human physiology in its relation to biology, 15 m. . . . . Guido Bell
3. A means of preventing hog cholera, 5 m . . . . D. W. Dennis
4. The Hopkins Seaside Laboratory at Pacific Grove, Cal., 10 m. . B. M. Davis
5. Infection by bread, 10 m. . . . . Katherine E. Golden
6. Simple apparatus for photo-micrography, 5 m. . . . . M. J. Golden
7. Sanitary science in the modern college, 10 m. . . . . Severance Burrage

GEOLOGICAL SUBJECTS.

*8. Glacial and Eolian Sands of the Iroquois and Tippecanoe River valleys, 10 m..A. H. Purdue
9. [1]The recent earthquakes east of the Rocky Mountains, 10 m..A. H. Purdue
10. [2]Some minor processes of erosion, 10 m....................J. T. Scoville
11. [3]Kettle holes at Maxinkuckee, 5 m........................J. T. Scoville
*12. Fossils from sewer trenches in the glacial drift, 15 m.....Wm. M. Whitten
13. Relief map of Arkansas, 10 m..........................John F. Newsom

MATHEMATICAL SUBJECTS.

14. Some skew surfaces of the 3d and 4th degree, 15 m...........C. A. Waldo
15. [4]A problem in gravitational attraction, 5 m....................A. W. Duff
16. Note relative to Peirce's "Linear Associative Algebra"..James Byrnie Shaw

PHYSICAL SUBJECTS.

*17. Some old and new experiments in sound, 10 m...............M. N. Elrod
18. Variation of a standard thermometer, 10 m...............Chas. T. Knipp
19. [5]A method of graphically representing the laws of falling bodies, 5 m..F. P. Stauffer
20. Rates of combustion in locomotive furnaces, 10 m............R. A. Smart
21. The influence of heat, the electric current, and magnetism upon Young's Modulus, 15 m.............................Mary C. Noyes
22. [6]The temperature coefficient of the surface tension of liquids, 15 m..Arthur L. Foley
23. Strains in steam machinery, 5 m..........................W. F. M. Goss
24. The viscosity of a polarized dielectric, 12 m..................A. W. Duff
25. [7]A modification of the ring method for permeability, 10 m......A. W. Duff
*26. Some peculiarities in the formation and descent of drops, 5 m..A. W. Duff
27. [8]The effects of changes of temperature and pressure on viscosity, 5 m...A. W. Duff
28. On the alternating-current dynamo, 15 m............W. E. Goldsborough

*Neither paper nor abstract furnished the Academy for publication: no further mention made in the proceedings.

NOTE: The titles set off by small numerals are discussed in the body of the proceedings under corresponding heads given in the foot notes.

1. The Charleston (Missouri) earthquake.
2. Some minor eroding agencies.
3. Kettle holes near Lake Maxinkuckee.
4. The gravitational attraction of a homogenous ellipsoid of revolution.
5. Graphic representation of the law of falling bodies.
6. The surface tension of liquids.
7. A method of measuring permeability.
8. Empirical formula for the temperature variation of viscosity.

CHEMICAL SUBJECTS.

29. [1]The influence of grape sugar upon the composition of certain fat-producing bacteria, 5 m .... Robert E. Lyons
30. A new method for the preparation of phenyl compounds with sulphur, selenium and tellurium, 5 m .... Robert E. Lyons
31. Camphoric acid, 15 m .... W. A. Noyes
32. Note on milk inspection, 5 m .... Geo. W. Benton
33. Ratio of alcohol to yeast in fermentation, 10 m .... Katherine E. Golden
*34. Note on crystallized silicon, 1 m .... W. B. Johnson

BOTANICAL SUBJECTS.

35. The circulation of protoplasm in the manubrium of *Chara fragilis*, 5 m .... D. W. Dennis
36. [2]Some beneficial results from the use of fungicides as a preventive of corn smut, 5 m .... Wm. Stuart
37. A new station for *Pleodorina*, 5 m .... Severance Burrage
*38. Certain plants as an index of soil character, 5 m .... Stanley Coulter
39. Forms of *Xanthium Canadense* and *X. strumarium*, 15 m .... J. C. Arthur
*40. An interchangeable clinostat of new design, 15 m .... J. C. Arthur
41. Some notes on wood shrinkage, 10 m .... M. J. Golden
42. Botanical literature of the State Library, 5 m .... John S. Wright
43. Microscope slides of vegetable material for use in determinative work, 8 m .... John S. Wright
*44. Embryology of *Hydrastis Canadensis*, 10 m .... Geo. W. Martin
*45. Some determinative factors underlying plant variation, 10 m. Geo. W. Martin

ZOÖLOGICAL SUBJECTS.

46. Hæmoglobin and its derivatives, 10 m .... A. J. Bigney
47. Effects of heat upon the irritability of muscle, 10 m .... A. J. Bigney
48. The evolution of sex in *Cymatogaster*, 20 m .... C. H. Eigenmann
*49. Variations in the cleavage of the *Fundulus* egg, 10 m .... Geo W. Martin

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*Neither paper nor abstract furnished the Academy for publication; no further mention made in the proceedings.

1. The effect of grape sugar upon the composition of certain fat-producing bacteria.

2. Fungicides for the prevention of corn smut.

THE STATE BIOLOGICAL SURVEY.

*Neither paper nor abstract furnished the Academy for publication; no further mention made in the proceedings.

TURKEY LAKE AS A LIMIT OF ENVIRONMENT AND THE VARIATION OF ITS INHABITANTS. BIOLOGICAL SURVEY REPORTS.

69.	I.	First report of Biological Station, 10 m.	C. H. Eigenmann
70.	II.	[2]Some of the physical features of Turkey Lake, 10 m. .	D. C. Ridgley
71.	III.	Hydrographic map of Turkey Lake, 2 m.........	C. Juday
72.	IV.	Temperatures of Turkey Lake, 5 m..................	J. P. Dolan
73.	V.	[3]Inhabitants of Turkey Lake in general, 3 m	C. H. Eigenmann
74.	VI.	*Hirudinea* of Turkey Lake, 1 m	Bessie C. Ridgley
75.	VII.	[4]*Rotifera* of Turkey Lake, 5 m.....................	D. S. Kellicott
76.	VIII.	*Clodocera* of Turkey Lake, 5 m......................	E. S. Birge
77.	IX.	[5]*Mollusca* of Turkey Lake, 5 m..................	R. Ellsworth Call
78.	X.	[6]*Odonata* of Turkey Lake, 1 m	D. S. Kellicott
79.	XI.	[7]Fishes and tailed batrachians of Turkey Lake, 5 m.	C. H. Eigenmann
80.	XII.	[8]Tailless batrachians of Turkey Lake, 1 m	C. Atkinson
81.	XIII.	Snakes of Turkey Lake, 5 m	H. G. Reddick
82.	XIV.	[9]Turtles of Turkey Lake, 5 m..................	C. H. Eigenmann
83.	XV.	Water birds of Turkey Lake, 2 m	N. M. Chamberlain
84.	XVI.	Flora of Turkey Lake, 10 m......................	O. H. Meyncke
*85.	XVII.	[10]Methods of determining variations, 5 m	C. H. Eigenmann
86.	XVIII.	Variation of *Etheostoma* of Turkey and Tippecanoe Lakes, 10 m..............................	W. J. Moenkhaus

*Neither paper nor abstract furnished the Academy for publication. No further mention made in the proceedings.

1. A report upon certain collections of phanerogams presented to the State Biological Survey.
2. A preliminary report on the physical features of Turkey Lake.
3. The inhabitants of Turkey Lake.
4. *Rotifera*.
5. On a small collection of mollusks from Northern Indiana.
6. The *Odonata*.
7. Fishes.
8. Batrachia.
9. *Testudinata*.
10. The study of vari tion.

ELEVENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The eleventh annual meeting of the Indiana Academy of Science was held in Indianapolis Friday and Saturday, December 27 and 28, 1894, preceded by a session of the executive committee of the Academy, 8 P. M. Thursday, December 26.

At 9 A. M., December 27, President Amos W. Butler called the Academy to order in general session, at which committees were appointed, other routine business transacted. After the disposition of the morning's business, papers of the printed program, under the title of "General Subjects," were read and discussed until adjournment at 12 M.

The Academy met at 2 P. M. in two sections—biological and physico-chemical—for the reading and discussion of papers. President Butler presided over the biological section and Prof. W. A. Noyes acted as chairman of the physico-chemical section. After the adjournment of the sectional meetings at 5 P. M. the Academy again met in general session at 7 P. M. After the disposition of some committee reports and other business, by request of the Academy, Mr. W. W. Pfrimmer read a new poem, subject: "The Naturalist," following which was the address of the retiring President, Mr. A. W. Butler, subject: "Indiana; A Century of Changes in the Aspects of Nature."

Following this evening session of the Academy was a meeting of the executive committee.

Saturday, December 28, 9 A. M., the Academy met in general session for the transaction of business, after which followed the reading and discussion of papers until adjournment, 12:15 P. M.

PRESIDENT'S ADDRESS.

INDIANA: A CENTURY OF CHANGES IN THE ASPECTS OF NATURE. BY A. W. BUTLER.

Out of the wilderness of the past has come our present civilization. From the fauna and flora of the wilderness-time proceeded the forms of life about us. The progress of this century is the marvel of history. Co-extensive with this progress are the changes in nature wrought by human agency. The story told by the witnesses of these things is incomprehensible. To the earliest pioneer a day spent in the present time would paralyze his faculties. To the student of to-day placed in the wilds of a century past would his wonder be any less? We can not comprehend what man hath wrought. Within our memories, a few there have been—here and there one—whose lives included the beginning of the white man's activity and who, much out of place in every feeling have seen the progress of the ages move by. We listen to their tales of the past, but who is there who can picture in his mind the natural conditions of those early days and the subsequent changings? Vague and imperfect are our impressions if, indeed, we have any conception of them

It is probable that the first white man within the boundaries of Indiana was the explorer LaSalle. His voyage was made about 1669.' The earliest settlements were established within the first quarter of the last century at Ouiatanon and Vincennes. Authorities do not agree as to which was settled first or the date of settlement. These were only trading posts. Their effect upon existing conditions was but small. Nor was it until the Americans began to occupy this region at the opening of this century that the old began to fade before the new.

Over the greater part of this State were spread dense forests of tall trees—heavy timber—whose limbs met and branches were so interwoven that but occasionally could the sunlight find entrance. There was little or no undergrowth in the heaviest woods, and the gloom of those dense shades and its accompanying silence were terribly oppressive. Mile upon mile, day's journey upon day's journey stretched those gloomy shades amid giant columns and green arches reared by nature through centuries of time. The only interruptions were the beds of water-courses; the poorer hillsides covered with underbrush; the smaller growth of the less productive uplands; the site of an extensive windfall—the record of a tornado's passage; the small area of second growth timber marking the former clearing for some Indian camp; the more or less extensive patches of meadow,

occupying ground on which the forest had been destroyed by Indian fires. To the west, in the valley of the Wabash, were wide meadows covered with long grass. In the northern third of our territory were prairies and sloughs alternating with wooded sand hills and reedy swamps, imperfectly drained by a network of sluggish streams, which in turn gave place to extensive marshes toward Lake Michigan.

The southern portion of the State was more heavily timbered. Perhaps nowhere could America show more magnificent forests of deciduous trees, or more noble specimens of the characteristic forms than existed in the valleys of the Wabash and Whitewater. The trees decreased in size to the northward, those along the great lakes being noticeably inferior. The number of coniferous trees was small and was confined to restricted areas. Those found were poor representatives of their species.

The forests were made up of many kinds of trees growing together indiscriminately. Here and there certain groups and occasionally a species were found predominating. In various localities the character of the forest was different. Oak, ash, hickory, maple, beech and elm were prevailing trees, varying much in number and proportion. In some places the Tulip Poplar (*Liriodendron tulipifera* L.) was very numerous, often attaining great size—the largest tree of the primitive forests.

Forty-two kinds of trees in the Wabash valley attained a height above 100 feet.[1] The tallest recorded being a Tulip Poplar, 190 feet in height. It was twenty-five feet in circumference and ninety-one feet to the first limb.[2] Many thousands grew over the State measuring from three feet six inches to ten feet in diameter. Numbers of Sweet Gum (*Liquidamber styraciflua* L.) in the more fertile ground in the southern part of the State, contended with the tulip poplar in height, and in beauty and symmetry exceeded it. They attained a height of 130 to 150 feet and were three to four feet in diameter at the base, often preserving almost the same size to the first limb.[3] In the oak woods there were giants too. The Red Oak (*Quercus rubra* L.), Scarlet Oak (*Quercus coccinea* Wangheim), Burr Oak (*Quercus microcarpa* Michaux), and White Oak (*Quercus alba* L.) reaching a girth of ten to twenty feet, and often a height of 125 to 150 feet. One instance is reported of a Scarlet Oak 181 feet high.[4]

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1. Prof. Stanley Coulter: The Forest Trees of Indiana, Trans. Ind. Hort. Soc., 1891, p. 8.
2. Dr. J. Schneck: Rept. Ind. Geological Survey, 1875, p. 512.
3. R. Ridgway: Proc. U. S. National Museum, Vol. V, 1882, p. 67.
4. R. Ridgway: *Ibid*, p. 80.

In the southern part of the State, too, the Sweet Buckeye (*Æsculus glabra* Willdenow) attained great size, often being three feet six inches and four feet in diameter with trunks as straight as columns, the trees reaching a total height of over 100 feet. One example of this species is unique. It is the tree from which was made the celebrated buckeye canoe of the Harrison presidential campaign of 1840. The tree grew in the southeast corner of Rush county and is said to have been, when standing, twenty-seven feet nine inches in circumference and ninety feet from the ground to the first limb.[1] Here and there, quite thickly scattered, would be found groves of the finest Black Walnut (*Juglans nigra* L.) trees the world has ever known. Some of these groves were quite extensive, containing hundreds of trees, individuals of which were four to six feet in diameter and 100 to 150 feet high.[2]

In the river valleys, along the streams, the great size of the Sycamore (*Platanus occidentalis* L) was noticeable. This was the largest of the hardwood trees, reaching a maxium height of 140 to 165 feet and often measuring five to ten feet in diameter.[3] Keeping those company were the Cottonwoods (*Populus monilifera* Aiton), the larger of which measured five and even eight feet through and 130 to 165 feet high. The beauty of all the trees of this region was the White Elm (*Ulmus americana* L.). Its diameter sometimes reached five feet, and its height 120 feet or more, the ambitus often spreading over 100 feet.

At the time of its settlement the southeastern third of our territory, including all the Whitewater Valley, contained no Indian towns and was unoccupied by them save as occasionally a hunting or a war party passed through it. In the valley of the Wabash and in the northeastern part of the State were Indian villages, located because of natural advantages. These have been apparent to the whites, who in several instances established upon their sites settlements which have since become prominent as towns or cities. Among these Kekionga (Ft. Wayne), Chip-kaw-kay (Vincennes) and Ouiatanon (on the west side of the Wabash River, four miles below Lafayette[4]) were selected as trading posts by the whites, being centers of the finest game regions occupied by man within the limits of the present State. The peltry from the last-mentioned post, in one year, in those early times amounted to about eight thousand pounds sterling.[5]

1. W. P. Shannon: Proc. Ind. Acad. Science, 1894, p. 130.
2. R. Ridgway: Proc. U. S. National Museum, Vol. V, 1882, p. 76.
3. R. Ridgway: *Ibid*, p. 73-75.
4. Prof. Oscar J. Craig: Ouiatanon, a Study in Indiana History. Ind. Hist. Soc., pubs. Vol. II, No. 8, p. 3.
5. Prof. Oscar J. Craig: *Ibid.*, p. 22.

In different localities under different conditions were different forms of life. We have noted this regarding plants. It was so concerning animals.

American Bisons (*Bison americanus* Gmelin), generally known as Buffaloes, ranged in countless numbers over the meadows and prairies at the time we first learn of them. The Whitewater and Miami valleys formed routes to the Ohio River and the Big Bone Lick in Kentucky. The Wabash Valley became another avenue for their journeys, and the old trail from the prairies to the Kentucky barrens crossed the Wabash River below Vincennes. Over this wide, well-marked road, evidences of which still remain, countless thousands of Bisons passed annually. From the Ohio River to Big Bone Lick was a wide road which these animals had beaten "spacious enough for two waggons to go abreast."[1] Evidence of their former abundance is preserved in the swamps about this lick. In places their bones are massed to the depth of two feet or more, as close as the stones of a pavement, and so beaten down by succeeding herds as to make it difficult to lift them from their beds.[2] At the Blue Licks in Kentucky we are told in 1784: "The amazing herds of buffaloes which resort thither, by their size and number, fill the traveler with amazement and terror, especially when he beholds the prodigious roads they have made from all quarters, as if leading to some populous city; the vast space of land around these springs desolated as if by a ravaging enemy, and hills reduced to plains, for the land near these springs is chiefly hilly."[3] In the region that was densely wooded the Bisons were only seen as transients, but in the meadows and prairies they abounded. From the summit of the hill at Ouiatanon we are told, in 1718: "Nothing is visible to the eye but prairies full of buffaloes."[4]

Elk (*Cervus canadensis* Erxleben) were common, and Deer (*Cariacus virginianus* Gray) still more so. Bear and wolves were quite abundant. In one favorite locality, it is reported, a good hunter, without much fatigue to himself, could supply daily one hundred men with meat. Beaver (*Castor fiber* L.) were found in many localities. Especially favorable to them were the more level regions to the northward. Otter (*Lutra canadensis* Sabine) were quite common, while the Wild Cat (*Lynx rufus* Raf.), Canada Porcupine (*Erethizon dorsatus* F. Cuvier) and Panther (*Felis concolor* L.) were numerous.

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1. Journal of Colonel Croghan: Butler's History of Kentucky, 1834, p. 368.
2. Dr. A. W. Brayton: Rept. of Geological Survey of Ohio, Vol. IV, Pt. I, Mammals, pp. 75-77.
3. W. T. Hornaday: Rept. U. S. National Museum, 1887, pp. 387, 388.
4. Paris Documents, 1718: Colonial Hist. N. Y., Vol. IX. p. 891.

Of snakes especially noticeable for their abundance were Rattlesnakes (*Crotalus horridus* L., and *Sistrurus catenatus* Raf.) and Copperheads (*Agkistrodon contortrix* L.).

The ponds, sloughs and deeper swamps were the homes of many species of fishes, mollusks and crustaceans. The creeks, shaded by the closely crowding trees, contained water all the year round and in them smaller fishes reared their young. The rivers were clogged and dammed with fallen trees and driftwood and the water, when the streams were swollen by heavy rains, pouring over these obstructions, cut deep holes, which became the homes of great numbers of the larger fishes.

Wild Turkeys (*Meleagris gallopavo* L.) were found in large flocks. Bobwhites (*Colinus virginianus* L.) were so numerous that when they collected in the fall as many as a hundred were taken in a day with a single net. Ruffed Grouse (*Bonasa umbellus* L.) were abundant. Ducks and geese, snipe and plover were found in inestimable numbers where favorable conditions existed. Paroquets (*Conurus carolinensis* L.) were more or less numerous over the entire region and in the lower Wabash and Whitewater valleys were as abundant as blackbirds now are in spring and fall. Passenger Pigeons (*Ectopistes migratorius* L.) bred and roosted in many localities. During the migrations they appeared in such numbers that they obscured the sun and hid the sky for hours; sometimes for days in succession. The strange appearance was made more wonderful by the continuous rumble of the thunders of the oncoming clouds—the noise of the strokes of millions upon millions of wings.

Besides these, more rarely, Swallow-tailed Kites (*Elanoides forficatus* L.) and Ivory-billed Woodpeckers (*Campephilus principalis* L.) added their characteristic forms to the wild scenery. The Osprey (*Pandion haliaëtus carolinensis* Gmel.) and the Bald Eagle (*Haliaetus leucocephalus* L.) built their nests beside the streams and while one fished the other plundered the fisher.

Within the dense shades of the deeper woodland there was but a small number of birds. There quiet reigned. Twilight by day and densest darkness by night. How oppressive the awful quiet amid those gloomy solitudes! Everywhere the smaller birds were few compared with their present numbers.

But men of our race came upon the scene. Indians there had been there before. As it always has been, and so will continue to be, when two races, one superior, the other inferior, come into competition, the superior will overcome. The contest was inequal. The barbarism of the Ohio Valley could not hold its own against the alert and thoroughly equipped pioneer. Soon the native began to part with his land. It was not long until many sought other homes. Others

attempted to become permanent residents and to adopt, in some measure, the habits of the conquerors. The result is too well known. An ancestor of theirs gifted with the powers of a seer may have been the subject of these lines:

> " There was once a neolithic man, an enterprising wight,
> Who kept his simple instruments unusually bright;
> Unusually clean he was, unusually brave,
> And he sketched delightful mammoths on the borders of his cave.
>
> To his neolithic neighbors, who were startled and surprised,
> Said he, " My friends, in course of time we shall be civilized!
> We are going to live in cities and build churches and make laws;
> We are going to eat three times a day without the natural cause;
> We are going to turn life upside down about a thing called gold;
> We're going to want the earth and take as much as we can hold;
> We're going to wear a pile of stuff outside our proper skins;
> We're going to have diseases! and accomplishments!! and sins!!! "

One can not but be impressed with the significance of the design of "The Seal of the Territory of the U. S., N. W. of the River Ohio." Impressions of it are preserved in the Department of State, Washington, D. C. In the light of the development of the past century, of the changes that have been witnessed, it would be impossible standing here, at the other end of the century, to conceive a device more expressive or truer to facts. I quote from a work that has just appeared:

"A study of this historic seal will show that it is far from being destitute of appropriate and expressive meaning. The coiled snake in the foreground and the boats in the middle distance; the rising sun; the forest tree felled by the ax and cut into logs, succeeded by, apparently, an apple tree laden with fruit; the Latin inscription '*Meliorem lapsa locavit,*' all combine to forcibly express the idea that a wild and savage condition is to be superseded by a higher and better civilization. The wilderness and its dangerous denizens of reptiles, Indians and wild beasts, are to disappear before the ax and rifle of the ever-advancing western pioneer, with his fruits, his harvests, his boats, his commerce, and his restless and aggressive civilization." "*Meliorem lapsa locavit!*" "He has planted a better than the fallen!"[1]

The white man made the navigable water ways his routes and settled along them. At once, under his influence, the aspects of nature began to change. As in every other land the effects of man's settlement began to be seen. The need for food and clothing and the desire for tillable land were the great causes which impelled him to action. In every land, on every sea, the story has been the same. Before his aggression disappeared the most noticeable forms of life. The large or conspicuous species were those most easily affected—the ones which were

1. William Hayden English: Conquest of the Country Northwest of the River Ohio, Vol. II. 1896, p. 774.

first destroyed. The story of the disappearance of the great animals of Europe; of the Bison and the Urus; of the extinction of the giant birds of New Zealand; of Steller's Sea Cow and the Great Auk, one each upon our eastern and western coast; the most wonderful destruction of the great herds of the American Bison, and the threatened extinction of the Fur Seal in the North Pacific, and of the Zebra, Camelopard and other large animals in Africa, are notable illustrations of the greater changes that have been wrought. But there are smaller ones not so conspicuous but more potent in their influences upon human welfare.

The Bison, the most characteristic of all the animals of America, was the first to disappear from the region under consideration. Formerly it had ranged east, at least as far as western New York and Pennsylvania and in States farther south almost to tide water, but about 1808 it was exterminated east of the Wabash River. The Elk followed it closely, disappearing from the Whitewater Valley about 1810 and from the State in 1830. The Panther followed soon after. Virginia Deer, Bear, Otter, Beaver, Wolves and other forms were almost exterminated. Though of some, if not all, of these latter forms a remnant yet remains in some favored localities.

Turkeys and Bobwhites; Ivory-billed Woodpeckers and Wood Ibises (*Tantalus loculator* L.); Black Vultures (*Catharista atrata* Bartram) and Carolina Paroquets have been almost, or in a great measure, exterminated. The Paroquets which ranged to the great lakes and were so common a feature in the landscape of the pioneer times, have not only disappeared from Indiana, but from almost all the great range from Texas to New York over which they spread at the beginning of this century, and are, perhaps, now only found in a restricted area in Florida. The day of their extirpation is near at hand.

The Passenger Pigeon survived the beautiful little parrot until a later day. But nets and guns, a short-sighted people and inefficient laws have all but swept out of existence this graceful bird. It is now on the verge of extinction. We can no more appreciate the accounts given of the innumerable hosts of these birds of passage than we can of the incalculable multitudes of the Bisons three score years ago. The words of those who saw them, we are assured, do not in any way convey an adequate idea of the wonderful sights and sounds during a flight of Pigeons. Some of their roosts covered many miles of forest. There, as they settled at evening, the gunners from near and far began to collect for the slaughter. The loaded trees upon the borders of the wood were first fired upon. Then the shooters passed into the denser forest. Three or four guns fired among the branches of a tree would bring down as many two-bushel sacks of dead birds, while numbers of cripples fluttered beyond reach. After a number of shots over a considerable area—several acres perhaps—the whole roost would rise with a

deafening thundering which no one has attempted to describe and soar out of sight in the dusk of the early evening, while from the rising cloud came a noise as of a mighty tornado. As the darkness settled the birds descended and alighted many deep upon the branches of the trees, the weight being sufficient to break off many of the large limbs. Then the scene changed. The slaughter began in earnest. The rapid firing of guns; the squawking of the Pigeons; the breaking of the limbs of giant trees beneath the living weight; the continuous rumble arising from the whirr of countless wings; all illumined by the lurid lights of numerous torches and many fires produced an effect of which no words can convey a conception to one who has not experienced a night at a pigeon roost. Each year such scenes were re-enacted. Each year the slaughter went on. Less and less the numbers grew. Trapping and netting, supplemented by repeating guns, added to the power of destruction, and the Pigeons, whose numbers were once so great that no one could conceive the thought of their extinction, have dwindled until they are rarely found. One Pigeon in a year! Soon they will be but a memory.

The pioneers' first work was to cut away the trees and build a cabin. As each cabin was built, it foreshadowed a clearing extending more and more each year. The line of the Ohio and of the Wabash formed the basis for the advance of settlement. The ax and fire performed their work. Great deadenings gave promise of a lively time log-rolling next season. Giant Tulip Poplars; monster Black Walnuts; and Oaks, Ash, Wild Cherry (*Prunus serotina* Ehrhart) and Sweet Gums, the largest of their fellows, were rolled into heaps and burned. To this, in time, was added the necessity for fuel, for lumber and for timber to supply all the demands which human minds could make upon the forest, not only for our own population, but also for other States and other lands. Thus were our forests destroyed. Now, except in a few localities, there remains no virgin forest.

The destruction of the primitive woods cost much besides the trees that were sacrificed. Each tree was the host or resting place of other forms of life. Of the blight upon its leaves; of the fungus upon its limbs; of the lichen and moss upon its bark; of the birds among its branches; the insects on its foliage and about its blossoms; the borers within its body. And it sheltered other lowly, ground inhabiting forms beneath its spreading shades. Who can tell what the destruction of a tree signifies? How far-reaching are its effects! After the axe came fire, carrying destruction to the more inconspicuous animals and plants. Fire, too, swept the standing woods and in its blighting effects extended far beyond the immediate necessities of the pioneer. With the cutting away of the larger trees, in many localities, sprang up thickets and therewith came thicket-inhabiting animals. As the clearings were extended, meadow lands and pasture lands were reserved.

To the meadows came such forms as the Bay-winged Sparrow (*Poocætes gramineus* Gmelin), Field Sparrow (*Spizella pusilla* Wilson), Grasshopper Sparrow (*Ammodramus savannarum passerinus* Wilson), Meadow Lark (*Sturnella magna* L.), meadow mice, garter snakes, green snakes, bumble bees and grasshoppers—species peculiar to such surroundings. Some parts of this land were wet and where the drainage was poorest, became swamps and sloughs. There, forms which love such places, came. Among them Marsh Wrens, Swamp Sparrows (*Melospiza georgiana* Lath.), and Red-winged Blackbirds (*Agelaius phœniceus* L.), salamanders, frogs, water snakes, aquatic insects and marsh plants. As the orchard and garden developed, birds well known to us and greatly beloved for their cheery social ways, there made their home and lived upon food brought to the locality by the changing conditions. The number of settlers increased, causing a steady diminution in the numbers of all the larger mammals, especially those used for food or valuable for fur; of geese, ducks and other water loving birds. The early settlers had brought with them the Black Rat (*Mus rattus* L.). Later another form, the Brown Rat (*Mus decumanus* Pallas), which, like the first, was a native of the old world, appeared, following the routes of civilization. It drove out the other rat and has since occupied its place. The shy Gray Fox (*Urocyon cinereo-argentatus* Schreber), disappeared in advance of the incoming pioneer and the Red Fox (*Vulpes vulpes* L.) occupied the field left vacant. The hog, a most valuable factor in the development of the West, proved equally valuable as an ally in the warfare against snakes. Largely through its efforts were the rattlesnakes and copperheads destroyed.

Removing the timber and breaking the ground began to show its effect upon springs and water courses. Many became dry during the warm season. All life, be it salamanders, fishes, mollusks, insects or plants, that found therein a home, died. As time went on drainage became a feature introduced into the new country. With the draining of our sloughs and swamps other changes came. The birds that lived among their reeds and flags, mingling their voices with those of the frogs, disappeared, and the land reclaimed tells, in its luxuriant growth of corn, no story to the casual passer-by of the former population which occupied it.

And so it was. Change succeeded change. Little by little, but still each cleared field, each drained swamp, each rotation of crops, each one of a thousand variations in cause had its effect upon the numbers and life histories of our plants and animals.

When the Indians left, the prairies were no longer annually burned over. Forest vegetation began to seize upon this open land, and in time much of it became reforested. Into it was brought life from the surrounding woods, and the former occupants were driven out.

With the thinning of the trees appeared an undergrowth. Where the undergrowth came, and where the second growth appeared in neglected clearings, the vegetation was often different from that of the original forest. This, too, was destined to go the way of passing things.

The Ginseng (*Panax quinquefolium* L.), Spikenard (*Aralia racemosa* L.), Bloodroot (*Sanguinaria canadensis* L.), and Yellowroot (*Hydrastis canadensis* L.), and many ferns are following the woody plants to extermination.

Milksickness, once so prevalent among the early settlers, with the peculiar fevers of the new country, are of the past. Staggers has disappeared from many places, yet the Wild Larkspur (*Delphinium tricorne* Michaux), which, traditionally, is its cause, has become more abundant in some congenial localities, and in such neighborhoods the disease is quite serious.

But there are other results of the introduction of civilization which have made themselves felt. The streams were dammed and the migratory fishes prevented from ascending them. The driftwood disappeared from the streams. In time the dams, too, were gone. The deep holes, where the fishes loved to hide, filled up. The streams carried less water through the summer. Dynamiting, netting, and other illegal means of fishing became prevalent. All these have combined to wage a war of extermination against the inhabitants of our streams and lakes which might, if properly protected, prove an exceedingly valuable factor alike in the enjoyment and in the food supply of our people.

The telegraph wire is very destructive to birds. Birds and insects have found a new instrument of destruction in the electric light. Railroad tracks have proved very deadly to many living things besides man. They, in turn, are highways along which the cars introduce new forms of plants and animals. The self-binder and the mower play havoc with the lives of many inhabitants of the meadows and grain fields.

Following in the civilizer's footsteps have come other changes. Man has not only made the wilderness to blossom as the rose and gathered fruits and grain from all lands for the necessity and enjoyment of our people, but with the grain has been sown tares and with the fruit has been planted blight. Teasles (*Dipsacus sylvestris* Hud.), Canada Thistles (*Cnicus arvensis* Hoffm.), Wiregrass, Platains and Prickly Lettuce (*Lactuca scariola* L.) are contending for the soil. Pear blight, smuts, rusts and Black-knot affect fruits and flowers. Chinchbugs (*Blissus leucopterus* Say), Hessian Flies (*Cecidomyia destructor* Say), Colorado Potato Beetles (*Doryphora decem-lineata* Say), Clover-root Borers (*Hylesinus trifolii* Mull.), Scale Insects and Cabbage Worms dispute with the farmer his right to the crops he has planted.

Some of the native forms of life have, in some respects, changed their habits. This is evidenced by the Rose-breasted Grosbeak (*Habia ludoviciana* L.) feeding upon the Colorado Potato Beetle. The destruction in the rice fields of South Carolina caused by the Rice birds—our Bobolink (*Dolichonyx oryzivorus* L.). The loss inflicted in the rice swamps of Louisiana by the Red-winged Blackbird. The damage done to the western corn grower by the Bronzed Grackle (*Quiscalus quiscula æneus* Ridg.)—our common Blackbird. By man's agency the European House Sparrow, or "English Sparrow" (*Passer domesticus* L.), was introduced, and, as its numbers increased, it began to assert itself in the struggle for existence. The Bluebird (*Sialia sialis* L.), which had come from the hole in the snag, was driven from her box. The Martin (*Progne subis* L.), which, like the Chimney Swift (*Chætura pelagica* L.), formerly nested in hollow trees, left its nesting sites about the house, and even the Eave Swallow (*Petrochelidon lunifrons* Say.), which, in olden times, fastened its nest to the cliffs, was, in some cases, driven away. The warfare with this aggressive little foreigner still continues, worse some places than others. But it has such surprising powers of reproduction and such unheard of audacity it seems they must soon cover our entire continent. The history of the German Carp (*Cyprinus carpio* L.) in this country illustrates the same persistent and successful struggle for the mastery in our water ways that has been noted of the House Sparrow on the land.

In time fashion demanded of that which neither man's appetite nor his need for protection had impelled him to take. Her altars were erected and upon them sacrifices of animals—a host innumerable—were offered. Fur bearing animals and bright plumaged birds were most earnestly desired, but even the shells of turtles, the skins of snakes, the teeth of alligators and the pearls of fresh water muscles were acceptable offerings. The extent of the destruction of innocent bird lives alone is appalling. A few facts may convey some idea of this. Among the items of one auction sale in London were 6,000 Birds of Paradise; 5,000 Impeyan Pheasants; 360,000 assorted skins from India; 400,000 Humming birds. One dealer in 1887 sold no less than 2,000,000 bird skins.[1] It is probable not less than 5,000,000 birds were required a year to supply the demand in this country alone when the bird-wearing "craze" was at its height. From information obtainable it is certain that hundreds of thousands of birds must have been slain in the United States for the glory of fashion's devotees. To this great number of victims our own State has been, to a greater or less extent, a contributor. Many counties in Indiana were visited by bird hunters. It is said from Indianapolis alone 5,000 birds, prepared for millinery purposes, were shipped in one year.[2]

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1. Lucas. Report U. S. National Museum, 1889, p. 611.
2. Science. Vol. VII, 1886, p. 240.

Under our present law, which seems to be well enforced, it is a pleasure to say our birds are apparently free from that danger.

Changes still continue. The future will record them as has the past. Those to come promise to be more fruitful of results, to be of greater moment to mankind, to bring more earnest messages for human weal or woe. But no time in the future will the changes in the aspects of nature here be so noticeable, so incomprehensible, because of their vastness, as have those of the century just closing.

UNCONSCIOUS MENTAL CEREBRATION. BY C. E. NEWLIN.

If it be true, as Dr. Kay says, that "our mental progress is in the direction of our becoming unconscious, or largely unconscious, of many of our ac:ivities," and "the great object of education should be to transfer as much as possible of our actions from the conscious to the unconscious regions of the mind," it seems to me our efforts should be more largely directed to the training of the mind in its *method of acting*, and less to the accomplishing of definite tasks. It seems to me that much of our failure in accomplishing results is caused by the very *effort* to accomplish them. The worry over the effort and the intense desire to succeed incapacitates the mind for clear action. If we could only be oblivious to the effort to think out a problem in any phase of life we would more easily reach the desired end. As in riding on a smoothly moving train, we are unconscious of the motion until we look out on the passing objects, so we should be entirely unconscious of the vehicle of thought and the ends to be attained, and let the mind attend to its *thinking* unhindered.

Dr. Mandsly says: "The interference of consciousness is often an actual hindrance to the association of ideas."

Much of this desired condition is attained through cultivation of the faculties. When an action becomes a habit the reflex action is unconscious. Dr. Kay says: "The more we cultivate and train any faculty or power, the more easily and rapidly does it perform its work; the less consciousness concerned in it the more work does it accomplish and the less does it fatigue."

Dr. Morrell says: "A purely unconscious action is accompanied by no fatigue at all." In my investigation I am convinced he is very nearly, if not entirely, correct. For example, the receiving teller of a bank will run up the long columns of figures in adding with ease, and fatigue only to the extent of his consciousness of his acts.

But I am convinced this is not altogether a matter of practice. It is partly due to the *method* of thought. He reads the figures and their combinations much as one reads words, without thinking consciously of each letter in the words. A

bill clerk will extend the totals of goods as quick as he can write them when the number of articles or yards and the price are given. Some accountants will add two or three columns at once almost as rapidly as he would read the same length of printed words.

When in school I was given the problem of running a railroad much in the shape of a letter S through three given towns. After working four days on it and late into the night I decided to give it up, and prepared to retire. My instruments and figures still lay spread out on the table, and as I passed the table to hang up my coat unconsciously my eyes fell on the figures, and the solution came to me instantly, and I solved it and drew the figures in less than a minute. I do not believe I would ever have solved it if I had not given it up and thus relieved my mind of the intense consciousness of the effort to solve it.

When my father was a young man teaching school he had given his class a long problem in partial payments. The class failed to solve it, and when he tried it he failed also. Being unwilling to let them know he had failed, he worked on it every spare moment for several days. One night he worked at it until late at night, failed again, decided to give it up, and retired. In the night his mother heard him marking on the slate in the dark room and asked him what he was doing. He told her in his sleep he was trying to solve the problem. She let him work on for some time, when he again retired. He did not waken until called to breakfast the next morning, and when questioned in regard to the problem said he had failed to solve it and had given it up for good. In the meantime his mother had turned the slate over. His father insisted he should not give it up, and induced him to try it again. He did so, working on the other side of the slate, but he again failed. On turning the slate over they found he had solved the problem correctly, covering the entire side of the slate with his work, in his sleep and in a dark room, and yet remembered nothing of it and could not solve it the next morning. This seems such a remarkable case that I thought it worthy of giving to you as an illustration.

My conclusions are that we are wasting much time in life with simple mental acts that should be done unconsciously, and our very consciousness often defeats the effort. It seems to me we should spend more time learning *how* to think, and in concentrating our mind on the matter in hand regardless entirely of all accompanying subjects or the result of our thought. If this be true the "To learn to do by doing" does not cover all, nor the most important, of the ground.

Means of Preventing Hog Cholera. By D. W. Dennis.

During the spring term of 1894 I gave twelve chapel lectures at Earlham College on the conquest of disease. In one of these lectures I discussed the late cholera pestilence in Hamburg and presented a bulletin like those posted up throughout the city, directing the sterilization by boiling of every article of food and drink and of all infected utensils and clothing. I called attention to the fact that science had not only kept the plague from crossing the ocean, but had limited it by a single street in the city of Hamburg itself.

Mr. Porter Cook, of Wilkinson, Hancock County, was a student with us at that time. His father, Mr. Lorenzo D. Cook, had lost by hog cholera what he supposed was at least 50 per cent. of his hogs for the ten previous years. The disease had been among his hogs every year, and he had lost some years as high as five out of every six. It was the habit of the disease to break out during the summer months among the hogs destined for the following November market. When Mr. Cook returned home at the end of the term he found the disease beginning among their hogs as usual. He at once determined to try the effect of sterilizing all the drinking water given to the hogs by boiling it with a little corn or wheat in it to give the hogs a relish for it. The two that were then sick of the cholera got well and there has been no cholera on his place since. He has never permitted his hogs to drink anything but boiled water since.

During last month a neighbor on the west has lost seven out of eighteen; a neighbor on the north had a hundred head; the cholera broke ont among them and he sold all but twenty-five, and of this number he thinks four will recover. A third neighbor has lost eight out of seventeen. There could not be a more satisfactory single experiment tried.

On a farm that had not for ten years escaped the disease, no case has occurred since the water has been boiled, *i. e.*, for two years, and during these two years every adjoining neighbor has been continuously troubled with the disease.

Mr. Cook says that his hogs have contracted a liking for boiled water and that they will not drink rain water when it gathers in pools in the fields, but wait for watering time instead. Two other facts which have come to my notice strengthen the view that boiling the water will entirely prevent the disease. A farmer in Wayne County never has had the cholera among his hogs. None of his neighbors' hogs have escaped the disease. Their hogs all drink from the neighborhood streams, his from a spring in his field. A farmer near Hillsboro, Ohio, when the disease was prevalent, divided a drove of 100 into two parts; half he watered from his well and the others at a stream. Of those watered at the well none died; of the others more than half. I have within the last week instituted a number of experiments, similar to the one Mr. Cook tried, in different

parts of the State where the disease is now prevalent, and I submit that the splendid results above given demand that a fair and extensive trial be made. In a large part of Indiana, namely, where there is natural gas, the experiment will cost but little either in money or trouble, and if it is efficacious as it seems to have been in this one case, to arrest the progress of the disease after it breaks out in the drove, it will very richly repay the expense and trouble in every part of the country. The question does not alone concern the farmer whose hogs die; it is the policy of many raisers to sell fattening hogs as soon as the disease breaks out, and there can be no question that much diseased meat is every year on the general market.

Prof. Noyes, of the Hygienic Laboratory of Ann Arbor, writes me, under date of December 20th, that he does not know of any experimentation on a large scale along this line. He has, I know, given much attention to the diseases, and would be likely to know of such experiments if they had been made. Both the general government and the governments of several of the States are spending large sums of money at experiment stations for the arrest of this disease. The results so far reached, interesting from a scientific standpoint, are useless in the field because of the skill and expense which the application of the remedies requires. The purpose of presenting this paper here is to secure, if possible, the co-operation of a hundred stock-raisers in different parts of the State, and differently surrounded, that a demonstrative test of this simple remedy may, in the next twelve months, be had. The animals experimented upon must be isolated from all sources from which they can obtain drink, and given only water to drink which has just been boiled; it should be served as hot as the hogs will drink it in clean troughs. Can we secure these experiments tried in this way. Six dips in Jordan and one in Parphar will be no experiment at all. It would be worth while for us to show, if we can, that on the White River, also, the simple is the sublime.

The "Hopkins Seaside Laboratory" at Pacific Grove, Cal. By B. M. Davis.

[Abstract.]

The great variety in fauna and flora, both in inland and marine forms, make the Pacific Slope and Coast, particularly that included in California, attractive to naturalists. As soon as Dr. Oliver P. Jenkins and Dr. Chas. H. Gilbert took their places in the Stanford faculty they recognized the resources of the coast from the standpoint of biologists. They immediately began to consider plans for establishing a biological station on the coast, and, after a careful survey of the whole coast, decided on Pacific Grove as the best location. The first substantial

aid was $300 given by the town of Pacific Grove, and $500 given by the Pacific Improvement Company. With this a temporary establishment was maintained.

This beginning was put on a firmer basis by the generosity of Mr. Timothy Hopkins, a resident of San Francisco, and the present laboratory, known as the "Hopkins' Seaside Laboratory," is the result.

Pacific Grove is on Monterey Bay, two miles from the old California capital of Monterey, and is reached by a branch of the Southern Pacific Railway and by the Pacific Steamship Line. The coast is irregular and rocky, yielding great variety of forms. Working material may be gotten from the Chinese and Portugese fishermen, both of whom have villages there.

There are two buildings; the older one contains three general laboratories, a supply room and seven rooms for investigators; the other building has a general lecture room, library room, a general laboratory, ten rooms for investigators and a dark room for photographic work. The basement is designed for aquaria. The library and apparatus of Leland Stanford University is used. Each student is provided with a compound microscope, reagents and all accessary apparatus needful in his work. Salt and fresh water is in both buildings and so distributed that each student may preserve his collections. The investigators' rooms are similarly provided. The laboratory provides for three classes of students:

First. Investigators who are capable of carrying on independent researches in morphology or physiology.

Second. Students of Stanford University, who wish to pursue their work under more favorable circumstances and gain knowledge of practical methods of research.

Third. Students and teachers interested in biology, who wish to become acquainted with recent biological methods. For these courses of lectures are provided, supplemented by individual instruction at the work tables.

The spirit of the school is excellent. No hours are definitely appointed, but students may be found at work from early in the morning until late at night. Although the laboratory has been open practically only three years the advancement already made and the evidence of increasing interest assure its future prosperity and growth.

Infection by Bread. By Katherine E. Golden.

In recent years, since the subject of bacteriology has made such headway, there have been numerous scares among the people; sometimes it is tuberculosis in milk and meat, then the development of ptomaines in fish, clams, canned goods, etc., the list going on indefinitely. Among these the dangers from bread baked

in basements, in "sweat shops," and by people who were not sufficiently clean, personally, have been dwelt upon in newspapers, and even in the Century Magazine an article appeared a year or so ago from a prominent member of the New York Board of Health, advocating certain methods of making bread in which baking powder should be used instead of yeast, so as to do away with the kneading and the consequent handling of the dough. Some of the cooking school teachers have advocated the same thing, claiming in addition that in bread not thoroughly cooked the yeast is not killed, and that on its introduction into the stomach a fermentation is set up.

To test the validity of these claims I made a number of experiments upon breads gotten from Lafayette bakers, the breads being obtained from the grocers, the object for which they were to be used not being stated. Specimens of the ordinary loaves, and also rolls that require a shorter time in baking, were obtained, an attempt being made also to select those specimens showing the least baking. In making the tests care was taken that outside germs should not be introduced. I first washed my hands with corrosive sublimate solution, then singed the outside of the loaf by means of a gas flame; the loaf was then broken open and a piece of about one gram weight taken from the center with sterilized forceps and placed in test tubes of sterilized beer wort. The specimens of bread were allowed to remain in this medium for about ten days, then plate cultures were made, the gelatine for the plate cultures being inoculated from the wort in the tubes. Duplicate experiments were made of each specimen of bread used.

Beer wort is one of the best media for the cultivation of yeast, as it contains an abundance of the food necessary for its growth. It is also valuable as a medium, as it becomes turbid by the growth and froths readily in the fermentation.

In the experiments in no case was there any apparent growth in the wort; it remained perfectly clear, and no gas was formed. In the plate cultures no growth took place, except in one case in which a mould grew. It is very probable this was introduced in the manipulation, as the duplicate showed no growth.

Duplicates of these experiments were made with bread obtained from Boston, with the same results. The Boston bread was bought in some of the large grocery stores and restaurants, which would, of course, insure the bread having come from reputable bakers. I was not successful in obtaining any basement made bread or that from so-called "sweat-shops" where the cleanliness is questionable.

Enough has been done, however, to demonstrate that yeast and the ordinary bacteria found in dough are killed in the baking, and that any germs introduced into the stomach by means of the bread have come from the outside of the loaf, and have been deposited upon it after the baking. If any doubt exists in one's mind in regard to the place from which he has obtained bread, it is very easy to

render the bread safe from living germs by singeing the surface with a flame. As the interior of a loaf of bread is raised to nearly 100° C. in the baking, besides steam being generated, the conditions are such that yeast can not live, and most bacteria can not resist this prolonged steam heat. The danger in bread is not the introduction of living germs into the system, but the introduction of ptomaines formed by bacteria during the rising of the dough. As the rising is done inside of six or seven hours, the danger from this source is very slight, as it would take considerably longer than that time for sufficient ptomaine to be generated to be injurious; moreover, the yeast is there in sufficiently large quantities to check the growth of any foreign organism, that must of necessity be there in small quantities.

Simple Apparatus for Photo-Micography. By M. J. Golden.

This device enables one to secure a photograph of a section with little loss of time, and with little disturbance of the section.

The device consists of a piece of board, about an inch thick, forty inches long and about twelve inches wide, to which are attached a shelf to hold the microscope, and a sliding piece with a pair of brackets to carry the box of an ordinary hand camera. Under the shelf another piece of board is fastened to the first, at right angles, and this assists in supporting the shelf, and serves as a leg to help keep the apparatus in an upright position.

The back, leg, shelf and sliding piece may be constructed from a piece of smooth pine board; and the bolts and nut used with the sliding piece are ordinary machine ones, that may be gotten at a hardware store. One of the bolts must have the same pitch as the hole in the camera box, by which it is fastened to the tripod. One may easily make this stand for himself, or have it made by a carpenter at little cost.

The lens of the camera is removed, and a funnel made of heavy, black cloth, or some corresponding material having flexibility, put in place of it, so that light-tight connection may be made between the camera box and the eye-piece of the microscope. If this cloth funnel be terminated in a small cone, made of tin or paste-board, to fit over the eye-piece, the adjustment to the microscope can be more rapidly made.

By using a camera box, one can also use the ordinary plate holders for his negatives, and he can get his focus on the ground glass. Of course, the plates may be developed at one's leisure.

The advantage of the apparatus is that one can, with slight cost, have at hand in the laboratory, means for making a permanent record of any peculiarity in a section that he may find, with the expenditure of very little time.

It will be found that greater uniformity in the negatives from the sections can be gotten by using an artificial light rather than natural light; a Wellsbach incandescent gas lamp gives good results.

SANITARY SCIENCE IN THE MODERN COLLEGE. BY SEVERANCE BURRAGE.

The modern college should reflect in its curriculum the best, the most advanced thought of the time on the physical as well as the mental and moral life of the people. Many old habits and customs which have been generally adopted into family life have been curtailed, leaving room for more modern ideas and discoveries.

One of the most profound changes in the latter part of this Nineteenth Century has been in our attitude toward the physical welfare of mankind, especially in regard to the causes and prevention of disease. This is no longer a matter of importance to the medical profession alone; in fact the physician deals mainly with the cure of disease, not its prevention; therefore, in order that the coming generation shall be prepared to meet and grapple with these vital problems, to apply the new ideas intelligently they must become familiar with the fundamental principles of sanitary science. This is particularly true in view of the extended growth of community life. The decline of individual responsibility, and the increase in one form or another of socialism, makes the necessity for public supervision doubly important. Public supplies are public dangers, and, therefore the supervision of them must be expert. The expert must be intelligent, and perhaps more important still, he must be backed by an intelligent public opinion. Here, then, are the two great vacancies to be filled—the expert sanitarian and the well informed citizen. No college should send out its students without some insight into this new science of the public health. Whether the course be compulsory or elective may be a matter of opinion, but the important bearing of such a training must be evident. This training should include a certain knowledge of sanitary chemistry, as applied to the analysis of air, water, milk, butter, cheese and other foods, as well as the principles of bacteriology, showing the importance of cleanliness in the home, in the public places of the community, and in the general habits of living. If the student is made to see, by actual laboratory experiment, that the air is full of dust, much of which is living matter in the form of mold and bacteria spores; if he examines a sample of milk and finds a million or more bacteria, and if he understands that wherever there is decaying animal or vegetable matter, there are myriads upon myriads of living microbes, then there is

one more citizen, who, after he graduates, will insist on a neatly kept house in a clean, healthy neighborhood; who will, we hope, find out who his milkman is, and what kind of milk he and his family are drinking. Then, moreover, he will understand the importance of having, in the thickly settled communities, efficient men, free from politics, to look after the public supplies of water, ice, milk and meat; the removal of garbage and disposal of sewage; the ventilation of public buildings and the cleaning of the streets, the isolation of contagious diseases, etc.

Aside from the importance of this work as shown above, it is a most valuable training for the young man or woman as a laboratory course. Dr. George M. Sternberg, Surgeon-General of the United States Army, in his address given in September before the Georgetown Medical College, gives very much importance to bacteriological work as a most excellent exercise for teaching the student to observe. This was meant particularly for the preparation of men for the medical profession, but accurate observation is desirable for, and often woefully lacking in our modern citizens, both men and women. The many delicate tests, chemical and physical, that are essential in modern bacteriology give exceptional opportunities for a training of this kind. The careful manipulation necessary in making microscopical preparations of bacteria, diseased tissues, etc., gives ample chance for the training of the hand as well as the eye.

The study of vital statistics, which to a certain extent should enter into a course of this kind, would necessarily show the need of accurate systems of registering births, deaths and cases of infectious diseases.

Much has been done in the last ten years toward establishing such courses in sanitary chemistry and biology, and the recent gift of Miss Culver to Chicago University, providing especially for departments in sanitary science and hygiene, shows clearly that the subject is not only in the public eye, but that its importance is even beginning to be realized. Indianapolis is alive to the subject, having this month passed the ordinance providing for the supervision of the milk supply and inspection of the dairies.

We see, then, that the rapid developement of applied biology and hygiene is calling for and must have intelligent, well-trained men and women to lessen the dangers that arise from public supplies of various kinds; to teach the children as well as the public, their duty from the sanitary standpoint toward their neighbors, and to assist in the solution of problems that are today perplexing physicians and scientists. Many of these wants can be, and are being supplied by the colleges and scientific schools, and the periodicals and the public press are earnestly pushing on the good cause.

It can hardly be less than an educational and scientific duty for us to see to it that the young people who are graduated from our modern colleges shall have at least a realizing sense of this new scientific development, all of which has grown up within the last forty years.

THE CHARLESTON (MO.) EARTHQUAKE. BY A. H. PURDUE.

The earthquake of October 31, 1895, is the greatest seismic disturbance that has occurred in the Mississippi Valley since the noted earthquake of 1811. Though nowhere intense enough to do great injury to buildings, it was perceptible over an area of more than 400,000 square miles.

A short time after the occurrence of the earthquake the writer communicated blanks to the teachers of science in seventy-five cities and towns in the States of Indiana, Illinois, Missouri, Arkansas, Alabama, Mississippi, Georgia, Kentucky and Tennessee, requesting information concerning the time, duration and intensity of the shock, together with the apparent course of wave movement, and subsequent phenomena. The major part of these blanks was sent to science teachers of Indiana with a view to determining, if possible, whether the great volume of gas removed in recent years has had any effect on the stability of the crust within the gas region. It seemed not unreasonable to suppose that the relief of pressure within the rocks from which gas has been removed has left them in a strain, in which case the earthquake waves might produce a collapse which would be indicated by their reinforced intensity.

Of the seventy-five blanks sent out, only thirty-nine were returned, consequently my information is not so complete as I had hoped to secure. Of the thirty-nine received, however, twenty-seven are from Indiana, so that the facts concerning that field are tolerably complete.

The reports sent in substantiate what the newspapers had already indicated, viz., that the epicentrum was in the vicinity of Charleston, Missouri. The person* reporting from that place says that the force was "sufficient to break several plate-glass windows, crack brick walls, and throw down brick chimneys." He also reports: "About four miles southwest of this place the ground was cracked open in several places, and sand and water were forced from the fissures, causing what are commonly known in this section as sandblows. For a few minutes afterward water spurted from several pumps." There were at least two

* A. R. Boon.

slight shocks immediately following the severe one, at intervals of ten or fifteen minutes. Subsequently earthquakes occurred on November 1 at 8:15 P. M.; November 2 at 9:50 A. M., and November 17 at 9:20 P. M.

A good deal of injury to buildings is reported from Cairo, Illinois. At that place there is reported to have been at least one shock each day during the first five days of November. During one day there were three shocks.

At Columbus, Kentucky, the shock was sufficient to crack brick walls and throw off plaster. As at Charleston the first shock was immediately followed by two others of less intensity. One subsequent earthquake is reported for November 1 at 8:00 P. M.

From nowhere else do the reports indicate such intense movement as at these three places, and from no other place is there an earthquake reported subsequent to the one of October 31st. As the three places are within a radius of twenty-five miles, the epicentrum can be considered fairly well located.

Reports from the Indiana gas field and vicinity indicate a movement slightly more intense than those from other parts of the State, but the increased force was not sufficient to justify the conclusion that it was due to the removal of gas. Three shocks in rapid succession are reported from Portland and Marion; two from Decatur, Goshen, Lafayette and Frankfort. From other places only one is mentioned. The average duration of the shock in six towns and cities within the gas region was 44.1 seconds. The average duration of the shock in sixteen towns and cities outside of the gas field was 43.2 seconds. That the apparent increase of intensity within the gas region and vicinity is not necessarily due to the removal of gas is shown in the reports from Bowling Green and Frankfort, Kentucky, each of which announces three shocks. Frankfort and Indianapolis are about an equal distance from the centre of disturbance. At Batesville, Arkansas; West Plains, Missouri, and Nashville, Tennessee, the shock is reported intense. At Wichita, Kansas, it was scarcely felt. At Atlanta, Georgia, it was slight.

Following the earthquake were increased flows of gas at Portland, Marion, and Bluffton. There were increased flows of water at Columbus, Shelbyville, Albion and Wabash. The water in Blue River rose several inches at Columbia City. The water in Pigeon Creek, Warrick County, rose one and a half feet the day following the earthquake, but soon subsided. Phenomena of this kind are a common result of earthquakes.

The average time of the shock as reported from Indiana was 5 o'clock, 10 minutes, and 30 seconds, A. M. There was no preceptible difference between the time the wave was felt in the southern part and in the northern part of the State.

This indicates either an extreme velocity of movement or great depth of disturbance, probably both. The large area affected and the comparative mildness of the shock at the epicentrum indicate that the disturbance was deep. A disturbance at a small depth might be felt over a large area, but if so, the force at the epicentrum would be great. According to the conclusions of Capt. Dutton from his studies of the Charleston (S. C.) earthquake,* the wave movement at that time had a velocity of about three miles per second. At this rate, it would require 1.38 minutes for a wave to travel from Charleston, Missouri, to Indianapolis. It will be seen that it would have required close observation to determine the difference in time at which the wave was felt at Evansville and at Indianapolis. The average time of the shock as reported from Charleston, Cairo, and Columbus was 5 o'clock 8 minutes and 20 seconds, or 2 minutes and 10 seconds earlier than the average time reported from Indiana.

An interesting feature of this earthquake is the fact that its epicentrum has approximately the same position as that of the earthquake of 1811 which resulted in the sinking of large areas about the mouth of the Ohio River for a distance of several feet.

There are newspaper reports of an earthquake at Cotapaxi, Colorado, November 18 at 4:10 P.M.; one at Greeley, Colorado, November 24th at 5 A. M.; and one at Clayton, Delaware, November 20, at 3 A. M. There was an earthquake of some severity reported from Rome and Naples, Italy, November 1. When we consider the great frequency of earthquakes in volcanic regions and in regions where there is great crustal disturbance, these closely simultaneous earthquakes in distant parts appear as probable coincidences hardly worthy of remark. It is reported† that in Japan there is an average of at least one earthquake a day. According to the records kept at Lick Observatory‡ there was an average of one earthquake for every 11.4 days in the State of California for the years 1890 and 1891.

* Ninth An. Rep. U. S. Geolog. Survey.

† Rep. Brit. Association, 1884, p. 242.

‡ Bull. U. S. Geolog. Survey, No. 79.

SOME MINOR ERODING AGENCIES. By J. T. SCOVELL.

The major or more effective erosive agents are: Heat and cold, air and water, plants and animals, wind, flowing water and ice.

The roots of growing vegetation sometimes open fissures in soils and rocks so as to hasten erosion, but generally growing vegetation is conservative in is action, serving to hinder the work of erosion. But decaying vegetation, especially trees, often open the ground to the water, and frequently a gully has its beginning from rain-water entering the ground along the decomposing roots of some ancient forest tree.

Burrowing animals, as the ground hog and gopher, the badger and prairie-dog, rabbits, mice and crayfish, bring loose soil to the surface, where it can be scattered by the wind or washed away by the rain. Air and water, by means of these openings, penetrate the ground with their disintegrating powers, and the cause of erosion receives material aid. Again, the track of a mole breaks the surface, and is the beginning of a drainage channel whose extent is limited only by the amount of rainfall and the steepness of the slope. Smaller animals of lower groups are also important erosive agents.

Darwin mentions earth-worms, and calls attention to the immense amount of work they do in working over the soil, rendering it more porous and fertile, and opening it to the action of more active agents, as air and water.

Burrowing spiders do a similar work; they are not as numerous as the earth-worms, but their burrows are wider and generally deeper than those of the earth-worm, so that, with fewer numbers, they still do a great amount of erosive work. They are abundant everywhere, in yards and fields, between the bricks of walks and by the roadside. Frequently they build a little curb of sticks, bits of grass or other material, so that the burrow somewhat resembles a well.

Grasshoppers aid in erosion when they open the ground for their eggs. They do not form a very large or a very deep hole, but when their great numbers are considered, it soon appears that they are erosive agencies of no mean proportions.

The male cricket in some localities does a work that is quite similar to that of the garden mole, only on a smaller scale. An immense number of the coleaptera spend a large portion of their larval stage underground. The entrance to their burrows and the opening for their escape stirs up the ground to the action of air and rain. Thus these humble workers contribute their mite toward keeping the land on the run toward the sea. The numerous family of burrowing beetles and many others as adult insects aid in this work.

The larva of the cycadia of different kinds, during their long period of life under ground, must do much toward pulverizing the soil. The larva of some of the tipulidæ, or crane flies, are among the most effective of these minor agencies. I found them last season working in shale and bowlder clay. These materials were honey-combed to a depth of about three inches below the level of the water, and so well was the work done that the mass broke down easily in the fingers. The materials removed in boring their tubes was quickly dissolved or washed away, and penetrating the holes the water rapidly dissolved the partitions or so weakened them that even a gentle current carried away the shale and clay in great quantities.

Many different kinds of ants burrow in the ground often ranging over large areas. The amount of soil worked over each year by these little laborers must be very great. Then there are several kinds of wasps which work more or less extensively in the soil. Some of the bees also work in the ground, or in banks much like cliff swallows. They deposit their eggs at the bottom of a hole or burrow some two or three inches deep. Often they build out an entrance or porch to the hole, possibly as a protection against intruders. Their work breaks up large areas of material each season for the rains of spring and autumn to dissolve and carry away. Many other insects are engaged in this work, but the ones mentioned are perhaps the more important. These little fellows are among the minor agencies of erosion, but the amount of work accomplished each year is immense and can not be neglected in a careful study of erosion and erosive agents. In nearly every case the action of these little animals serves to enrich and fertilize the soil, thus promoting the growth of vegetation while aiding in erosion.

KETTLE HOLES NEAR LAKE MAXINKUCKEE. By J. T. Scoville.

Kettle holes are phenomena incident to the retreat of glacial ice. They are very numerous in southeastern Massachusetts and are abundant throughout the glaciated area wherever the ice halted long enough to form morainic deposits. They vary greatly in size, but are usually somewhat conical in shape. They are often occupied by water forming ponds or small lakes. There are said to be more than 300 such bodies of water in Plymouth Township, Massachusetts. In many cases, however, their walls are of sand or gravel, which do not retain water for any great length of time, so that they are usually dry. The holes are supposed to have been formed somewhat as follows: The clay, sand, gravel and other morainic materials along the margin of the ice were irregularly distributed so that in some places it was so thick as to protect the ice underneath from the

action of the sun until the ice on all sides had disappeared leaving an island or detached portion of ice, thickly covered with rocky fragments, and often surrounded by a deep layer of similar material left by the more rapidly melting ice. The drainage channels abundant along the margin of the ice sheet often aided no doubt in detaching such blocks of ice.

As these masses melted down, their loads of debris would shoot down the sides, forming a rim, while the core, as it melted, would leave a hole or cavity, often reaching much below the general level of the surface.

Kettle holes are so characteristic in form that they may be easily recognized, and are indications of morainic materials that almost anybody can appreciate and understand. On the west side of Lake Maxinkuckee, between Marmont and the Arlington station there are seven or eight kettle holes ranging from 100 to 300 feet in diameter and from 4 or 5 feet to 25 feet in depth. Some have been partially cut away by the lake, others are quite perfect. One near the end of Long Point has been about one-half cut away, and the big ice house of Holt & Co. occupies a portion of an old kettle hole. The lake itself doubtless occupies a portion of an old drainage channel, the deeper portions being simply old kettle holes. It is interesting to study these remains or relics of the glacier, so symmetrical in form, so perfect in outline that they seem as if made but yesterday, as if fresh from the hand of the builder, making one feel sure that the ice is just over them a little way, and that the hills have just barely had time to clothe themselves with verdure since the ice king yielded up his scepter to the sun.

A Relief Map of Arkansas. By T. F. Newson.

[Abstract.]

In 1893 Dr. J. C. Branner constructed a relief map of Arkansas for the Arkansas exhibit at the World's Fair. The horizontal scale used was three miles to the inch; the vertical scale was 2,000 feet to the inch.

Topographic maps of the entire State were first made. These were cut into sections, and placed on small blocks cut to fit them. Pins were driven through the sections at prominent points, and were then cut to the proper vertical scale. These pins were the guiding points in molding the map, which was done in ordinary molders' clay. After being molded the separate blocks were fitted together, forming the complete model of clay, from which a plaster of Paris negative was cast. From the negative the positive or final cast of the map was made.

Some Skew Surfaces of the 3d and 4th Degree. C. A. Waldo.

[Abstract.]

The theory of skew ruled surfaces has been specially studied by Cremona, Cayley, Rohn and others. Rohn of Dresden has contributed several important series of models of general and fundamental character.

The object of this paper is to discuss somewhat in detail by Cartesian coördinates a family of surfaces formed by a straight line generatrix moving along two non-intersecting straight lines and a plane curve whose plane is parallel to both right lines.

Let the plane curve be $f(m, n) = Am^K + Bm^{K-1} + Cm^{K-2} + \dots L = 0$. Let the orthogonal projections of the straight lines on the plane of this curve be axes of X and Y, and their common perpendicular the axis of Z. Let the distance from the plane of the curve to one right line directrix be pb, to the other qb, the directrix parallel to the Y axis being the more remote. In this position, by similar triangles, it is easily shown that $m : x :: pb : pb - z$, and $n : y :: qb : z - qb$. Substituting these values in $f(m, n) = 0$ we have at once a general expression for the Cartesian equation of an unlimited number of skew surfaces of this description, viz.:

$$A\left\{\frac{pbx}{pb-z}\right\}^K + B\left\{\frac{pbx}{pb-z}\right\}^{K-}\cdot\left\{\frac{qby}{z-qb}\right\} + \dots L = 0$$

As shown by Salmon in another way the degree of this surface is at once seen to be twice that of the directing curve or twice the product of the degrees of the directing lines of the surface.

Plane sections of this surface are in general of the 2Kth degree, but when made by the plane Z=constant, they degenerate to the Kth degree.

If the directing curve be of the 2d degree the resulting surface will be of the 4th degree unless degraded by some special position. If we take the circle as our curvilinear directrix and place it half way between the two rectilinear directrices the resulting equation will be of the form

$$\frac{b^2x^2}{(b-z)^2} + \frac{b^2y^2}{(b+z)^2} = a^2 \quad (1).$$

If the circle be replaced by the equilateral hyperbola we have

$$\frac{b^2x^2}{(b-z)^2} - \frac{b^2y^2}{(b+z)^2} = a^2 (2).$$

If the directing curve be the parabola, $x\,n^2 = 4pm$, the surface is

$$\frac{by^2}{(b+z)^2} = \frac{px}{b-z} \quad (3),$$

a surface of the 3d degree.

In (1) if $b=a=1$, we have $x^2(1+z)^2+y^2(1-z)^2=(1+z)^2(1-z)^2$, a surface whose sections by planes perpendicular to the z axis give us between $z=0$ and $z=1$ ellipses of all possible eccentricities. A similar remark may be made of equation (2).

Among the deformations of which surface (1) is susceptible, one is worthy of special attention. If the threads representing the elements be weighted below the lower straight line directrix, and the upper directrix be then revolved until it comes into the plane of the lower directrix and the common perpendicular, the surface will gradually close up until it becomes a plane, but in every position the form of the Cartesian equation remains the same, while the axes of reference will be the equi-conjugate diameters of the ellipse cut out by the x y plane.

The Gravitational Attraction of a Homogeneous Ellipsoid of Revolution.

[Abstract.]

In this paper the following problem was discussed: Given an ellipsoid of revolution of given mass, but of variable eccentricity; find how its attraction on a particle at the end of the axis of revolution varies as the ellipsoid alters continuously from the infinitely prolate to the infinitely oblate form.

It was pointed out that this was the only case in which the expression for the attraction of a spheroid did not lead to elliptic integrals. An expression for the attraction in the above case was found by direct integration without recourse to the potential function. The integral took two forms according as the ellipsoid was prolate or oblate. The ordinary process of finding the value of the eccentricity corresponding to a maximum led to an insoluble equation. Hence the position of the maximum was approximated to by trial and interpolation. The conclusion was, that starting with the infinitely prolate form and passing through the spherical stage to the infinitely oblate form the attraction increased continuously, until that oblate stage was reached at which the axis of revolution was seventy-two hundredths of the equatorial axis, then it decreased until when the axis of revolution was fifty-one hundreths of the equatorial diameter, the attraction had fallen again to that at the spherical stage, from whence on it decreased to zero.

It was pointed out that this invalidates the common argument that the weight of a body at one of the earth's poles *must* be increased by the polar flattening.

NOTE RELATIVE TO PEIRCE'S "LINEAR ASSOCIATIVE ALGEBRA." JAMES BYRNIE SHAW, D. Sc.

I have no doubt many readers of Benjamin Peirce's classic work have found some difficulty in its perusal from the lack of examples of the algebras developed. That such a completion of the work was intended is shown by ¶ 2, p. 4, and the last three lines of page 119. The following method of exemplifying the subject may be of use or help. It is in a succinct form thus: Every unit in an algebra of this book is an operator of a matrical kind upon a ground of what we may call vectors. The whole work is thus a *treatise on groups of such operators.* This explains its abstruseness. Now for all cases in which the ground consists of two or three or four vectors, the units can be represented by the linear vector operators of quaternions, or linear quaternion operators. The relative forms given by Mr. C. S. Peirce may be immediately translated into such quaternion forms. Thus we may write, (α, β, γ, being vectors such that $S.\,\alpha\,\beta\,\gamma = 1$, and l_1, l_2, l_3, l_4, being quaternions such that $S.\,l_1\,A.\,l_2\,l_3\,l_4 = 1$ *).

Algebra a_1, $i = \alpha\,S.\,\beta\gamma\,(\;)$.

" b_1, $i = \alpha\,S.\,\gamma\alpha\,(\;)$.

" a_2, $i = \alpha\,S.\,\beta\gamma\,(\;) + \beta\,S.\,\gamma\alpha\,(\;)$; $j = \alpha\,S.\,\gamma\alpha\,(\;)$.

" b_2, $i = \alpha\,S.\,\beta\gamma\,(\;)$; $j = \alpha\,S.\,\gamma\alpha\,(\;)$.

" c_2, $i = \alpha\,S.\,\gamma\alpha\,(\;) + \beta\,S.\,\alpha\beta\,(\;)$; $j = \alpha\,S.\,\beta\gamma\,(\;)$.

" d_2, $i = l_1\,S.(\;)\,A.\,l_3 l_4 l_1$; $j = l_3\,S.(\;)\,A.\,l_1 l_2 l_3$.

" a_3, $i = \alpha\,S.\,\beta\gamma\,(\;) + \beta\,S.\,\gamma\alpha\,(\;) + \gamma\,S.\,\alpha\beta\,(\;)$; $j = \alpha\,S.\,\gamma\alpha\,(\;) + \beta\,S.\,\alpha\beta\,(\;)$;
$k = \alpha\,S.\,\alpha\beta\,(\;)$.

" a'_3, $i = \alpha\,S.\,\beta\gamma\,(\;) + \beta\,S.\,\gamma\alpha\,(\;)$; $j = \alpha\,S.\,\gamma\alpha\,(\;)$; $k = \alpha\,S.\,\alpha\beta\,(\;)$.

" a''_3, $i = -\,l_1\,S.(\;)\,A.\,l_3 l_4 l_1 - l_4\,S.(\;)\,A.\,l_1 l_2 l_3$; $j = -\,l_1\,S.(\;)\,A.\,l_3$
$l_4 l_1$; $k = -\,l_3\,S.(\;)\,A.\,l_1 l_2 l_3$.

" b_3, $i = -\,l_1,\,S.(\;)\,A.\,l_3 l_4 l_1 + l_2\,S.(\;)\,A.\,l_4 l_1 l_2 - l_3\,S.(\;)\,A.\,l_1 l_2 l_3$;
$j = l_1\,S.(\;)\,A.\,l_4 l_1 l_2 - l_2\,S.(\;)\,A.\,l_1 l_2 l_3$; $k = -\,l_1\,S.(\;)\,A.\,l_1 l_2 l_3$.

" b'_3, $i = -\,l_1\,S.(\;)\,A.\,l_3 l_4 l_1 + l_2\,S.(\;)\,A.\,l_4 l_1 l_2$; $j = l_1\,S.(\;)\,A.\,l_4 l_1 l_2$;
$k = -\,b_3 l_1\,S.(\;)\,A.\,l_1 l_2 l_3 + l_1\,S.(\;)\,A.\,l_4 l_1 l_2$.

" c_3, $i = -\,l_1\,S.(\;)\,A.\,l_3 l_4 l_1 + l_2\,S.(\;)\,A.\,l_4 l_1 l_2$; $j = l_1\,S.(\;)\,A.\,l_4 l_1 l_2$;
$k = -\,\alpha\,l_1\,S.(\;)\,A.\,l_3 l_4 l_1 - l_1\,S.(\;)\,A.\,l_1 l_2 l_3 + l_4\,S.(\;)\,A.\,l_4 l_1 l_2$.

" d_3, $i = \beta\,S.\,\alpha\beta\,(\;)$; $j = \alpha\,S.\,\alpha\beta\,(\;)$; $k = \alpha\,S.\,\gamma\alpha\,(\;)$.

" e_3, $i = -\,l_1\,S.(\;)\,A.\,l_1 l_2 l_3$; $j = -\,l_1\,S.(\;)\,A.\,l_3 l_4 l_1 + l_3\,S.(\;)\,A.\,l_1 l_2 l_3$;
$k = l_1\,S.(\;)\,A.\,l_4 l_1 l_2 - l_2\,S.(\;)\,A.\,l_1 l_2 l_3$.

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*) $A.\,l_2 l_3 l_4 = S.\,Vl_2 Vl_3 Vl_4 - Vl_2.\,V.\,Vl_3 Vl_4 - Vl_3.\,V.\,Vl_4 Vl_2 - Vl_4\,V.\,Vl_2 Vl_3$.
$S.\,l_1\,A.\,l_2 l_3 l_4 = -\,S.\,l_2\,A.\,l_3 l_4 l_1 = S.\,l_3\,A.\,l_4 l_1 l_2 = -\,S\,l_4\,A.\,l_1 l_2 l_3$.

Algebra g_4, $i = \alpha S.\beta\gamma(\,)$; $j = \alpha S.\gamma\alpha(\,)$; $k = \beta S.\beta\gamma(\,)$; $l = \beta S.\gamma\alpha(\,)$.

" bp_5, $i = l_2 S.(\,) A. l_4 l_1 l_2 - l_3 S.(\,) A. l_1 l_2 l_3$; $j = -l_2 S.(\,) A. l_1 l_2 l_3$; $k = -l_1 S.(\,) A. l_3 l_4 l_1 - l_3 S.(\,) A. l_1 l_2 l_3$; $l = l_1 S.(\,) A. l_4 l_1 l_2$; $m = -l_1 S.(\,) A. l_1 l_2 l_3$.

" bk_6, $i = l_1 S.(\,) A. l_2 l_3 l_4 - l_2 S.(\,) A. l_3 l_4 l_1 + l_3 S.(\,) A. l_4 l_1 l_2$; $j = - l_1 S.(\,) A. l_3 l_4 l_1 + l_2 S.(\,) A. l_4 l_1 l_2$; $k = l_1 S.(\,) A. l_4 l_1 l_2$; $l = -l_3 S.(\,) A. l_1 l_2 l_3$; $m = -l_2 S.(\,) A. l_1 l_2 l_3$; $n = -l_1 S.(\,) A. l_1 l_2 l_3$.

bm_6, $i = \alpha S.\beta\gamma(\,)$; $j = \alpha S.\gamma\alpha(\,)$; $k = \alpha S.\alpha\beta(\,)$; $l = \beta S.\beta\gamma(\,)$; $m = \beta S.\gamma\alpha(\,)$; $n = \beta S.\alpha\beta(\,)$.

These examples can be used to illustrate the general theorems. For example: "*Every group of linear vector operators contains at least one idempotent or one nilpotent expression.*"

The group $b\,m_6$ contains the idempotents

$$\alpha S.\beta\gamma(\,),\quad \beta S.\gamma\alpha(\,),\quad \alpha S.\beta\gamma(\,) + \beta S.\gamma\alpha(\,).$$

The group $b\,p_5$ contains only nilpotents.

"*When an algebra contains an idempotent expression it may be assumed as the basis and the remaining expressions are then divisible into four classes.*"

In $b\,m_6$ if we assume $\alpha S.\beta\gamma(\,)$ as the idempotent then the units are, with reference to the basis,

idemfaciend,	idemfacient,	$\alpha S.\beta\gamma(\,)$;
nilfaciend,	idemfacient,	$\beta S.\beta\gamma(\,)$;
idemfaciend,	nilfacient,	$\alpha S.\gamma\alpha(\,)$, and $\alpha S.\alpha\beta(\,)$;
nilfaciend,	nilfacient,	$\beta S.\gamma\alpha(\,)$, and $\beta S.\alpha\beta(\,)$.

"*The fourth class are subject to independent investigation.*"

"*If the first class comprises any units except the basis, there is, besides the basis, another idempotent expression or a nilpotent expression, and we may free the class from this, when idempotent, by writing for the basis the difference between the two; in this case expressions may pass from idemfaciend to nilfaciend or from idemfacient to nilfacient, but not the reverse.*" Thus, if we had taken for our basis in $b\,m_6$ $\alpha S.\beta\gamma(\,) + \beta S.\gamma\alpha(\,)$ there would have been only two classes,

1: $\alpha S.\beta\gamma(\,) + \beta S.\gamma\alpha(\,)$; $\beta S.\gamma\alpha(\,)$; $\alpha S.\gamma\alpha(\,)$; $\beta S.\beta\gamma(\,)$;

2: $\alpha S.\alpha\beta(\,)$; $\beta S.\alpha\beta(\,)$.

The second idempotent basis is easily seen to be $\beta S.\gamma\alpha(\,)$, and the difference is $\alpha S.\beta\gamma(\,)$, as before. And making this change of basis, $\beta S.\gamma\alpha(\,)$ and $\beta S.\alpha\beta(\,)$ become fourth class, $\beta S.\beta\gamma(\,)$ becomes second class, $\alpha S.\gamma\alpha(\,)$ becomes third class.

"*When there is no idempotent basis, all expressions are nilpotent, and all powers of each expression that do not vanish are independent. We may take any expression as the*

basis, but it is well to select one which has the most powers that do not vanish." Thus in $b p_2$ we take l_2 S. ( ) A. $l_1 l_1 l_2$ + l_3 S. ( ) A. $l_1 l_2 l_3$, whose square is $-l_2$ S.( )A. $l_1 l_2 l_3$, the cube vanishing. This algebra is then of second order. If A, B are any two expressions of it,

$$A^2 B + A B^2 + A B A + B A B = o.$$

These examples are sufficient to show the use of these forms in interpreting the subject. It remains only to show how they may be applied in a few cases. There are of course for every one of them two fields of application at once suggested by this method of writing them, viz.: linear transformations and homogeneous strains. E. g., the nilpotent algebra d_3. The general expression of this algebra is

$$\phi = x \beta \mathrm{S}.\, \alpha \beta\, (\ ) + \alpha \mathrm{S}.\, (y \mathrm{V}\, \gamma \alpha + z \mathrm{V}\, \alpha \beta)\, (\ ).$$

This transforms $\rho = x_1 \alpha + y_1 \beta + z_1 \gamma$ into

$$\begin{aligned} \phi \rho &= x z_1 \beta + \alpha\, (y y_1 + z z_1) \\ &= y y_1 \alpha + z_1\, (z \alpha + x \beta). \end{aligned}$$

This may represent any point of the plane (α, β). Since the value of x_1 does not enter $\phi \rho$, every straight line parallel to α is made to correspond to a configuration of the (α, β) plane. Those lines parallel to α which cut the (β, γ) plane in a line parallel to β, correspond to a series of configurations of the (α, β) plane produced by slipping it along the direction α. The movement of a line which is parallel to α along a line parallel to the line γ, produces a series of expansions of the (α, β) plane from a point $y y_1 \alpha$ as center. If both y_1 and z_1 vary, subject to a law, we have the configuration of the (α, β) plane

$$\phi \rho = y y_1 \alpha + f(y_1)\, (z \alpha + x \beta).$$

Again, consider the algebra a_3. The general expression here, is

$$\begin{aligned} \phi &= x\, (\alpha \mathrm{S}.\, \beta \gamma\, (\ ) + \beta \mathrm{S}.\, \gamma \alpha\, (\ ) + \gamma \mathrm{S}.\, \alpha \beta\, (\ )\,) + y\, (\alpha \mathrm{S}.\, \gamma \alpha\, (\ ) + \beta \mathrm{S}.\, \alpha \beta\, (\ )\,) \\ &\qquad + z\, \alpha \mathrm{S}.\, \alpha \beta\, (\ ), \\ &= \alpha \mathrm{S}.\, (x \mathrm{V}\, \beta \gamma + y \mathrm{V}\, \gamma \alpha + z \mathrm{V}\, \alpha \beta)\, (\ ) + \beta \mathrm{S}.\, (x \mathrm{V}\, \gamma \alpha + y \mathrm{V}\, \alpha \beta)\, (\ ) \\ &\qquad + \gamma \mathrm{S}.\, x \mathrm{V}\, \alpha \beta\, (\ ) \end{aligned}$$

ρ becomes $\phi \rho = \alpha\, (x x_1 + y y_1 + z z_1) + \beta\, (x y_1 + y z_1) + x z_1 \gamma$.

This strain operator will convert ρ into any other vector σ, for if

$$\sigma = \xi \alpha + \eta \beta + \zeta \gamma$$

we have at once from

$$\begin{aligned} \phi \rho &= \sigma, \\ x x_1 + y y_1 + z z_1 &= \xi, \\ x y_1 + y z_1 &= \eta, \\ x z_1 &= \zeta. \end{aligned}$$

Whence

$$x = \zeta / z_1,$$
$$y = \frac{\eta z_1 - \zeta y_1}{z_1^2},$$
$$z = \frac{\xi z_1^2 - \zeta (x_1 z_1 - y_1^2) - \eta y_1 z_1}{z_1^3}.$$

The exceptional cases are where $z_1 = 0$. That is, ϕ can be so chosen as to convert any vector into any other except those lying in the plane of (a, β), which is converted into itself, the line $x_1 a$ being converted into itself. The cubic of ϕ is $(\phi - x)^3 = 0$. We may write $\phi \rho = x \rho + (yy_1 + zz_1) a + yz_1 \beta$.

Hence the effect of any ϕ is to move the terminal point of ρ along its line in either direction, and then slide this extremity along a plane parallel to (a, β). Thus the infinite number of strains, which belong to this infinite group of strains, and that have the same x, represent a group of shears. Space nor time permit a fuller treatment of this interesting line of application of this algebra. The application of the other algebras might similarly be deduced.

I may say in closing that the natural classification of these algebras referred to by Professor Benjamin Peirce, who regarded his own classification as Linnean, is pointed to by these representations of the algebras.

ILLINOIS COLLEGE, Dec. 23, 1895.

VARIATION OF A STANDARD THERMOMETER. BY CHAS. T. KNIPP.

During the term just past I made a number of observations on a standard thermometer. The problem that presented itself was to observe the variations in a standard thermometer under given conditions, and the minimum limit of conditions that would produce the same.

Having a delicate cathetometer at hand, that reads directly to $\frac{1}{50}$ and accurately to $\frac{1}{100}$ of a mm., no hesitancy was felt in making the observations, feeling assured that the slightest variations in the reading of the thermometer could be detected.

The thermometer that was in question was one of Queen & Co's standardized thermometers of the centigrade scale, graduated in tenths over a range of 100 degrees. The bulb is cylindrical in form, thus having a maximum, or tending towards a maximum surface and consequently increased sensitiveness.

The thermometer was tested and standardized by the above named company on the 10th of October. After standardizing it was put in a brass case lined with

a rubber tube. The tube is closed at the lower end and is some shorter than the thermometer, so that a little pressure is required to push it in far enough to allow the cap to screw on firmly. This pressure is directly on lower end of bulb, and is more than a person would at first think. By repeated tests I found it equivalent to 240 grams, or a little over a half pound. Such a pressure acting continuously for some length of time would certainly change the shape of the bulb, and consequently the zero mark.

The length of the bulb is 25 mm. Its volume is approximately .3 cu. cm., as near as can be ascertained by measurement of its dimensions. The weight of the thermometer is 43 grams.

On the 16th of November, after a period of five weeks, the pressure was released, the thermometer placed in an ice and water bath and the exact position of the mercury column noted. Observations were made twice per week from that date, the last one being Saturday, December 21. Great care was taken in making these observations. The bulb was placed in an ice and water bath, while the stem for five inches above the zero mark was packed with finely broken ice. The added water was to equalize the pressure on the bulb. An aperture in the side of the vessel, through which passed a tube, the outer end of which guarded by a plane glass window made it possible to readily observe the mercury column, and yet have it completely surrounded with ice. Each observation extended over a period of three hours. To guard against jarring, the cathetometer and vessel holding the thermometer were placed on a stone pier.

The apparatus was allowed to stand for one hour before taking a reading, after which readings were taken every half hour. It was observed that when great accuracy was expected, all of an hour is required as the glass is very slow to take up the temperature of the melting ice and adjust itself accordingly, while the mercury takes up the temperature in a very few minutes. The first readings, therefore, are always too low. Before taking a reading the stem was jarred to facilitate the adjustment of the mercury. To prevent radiation the vessel was covered with a towel. After putting ice in the vessel it was thoroughly washed with distilled water. This last precaution was at first overlooked and the result was that the readings were far too low, *i. e.*. the melting mixture was made colder by its containing foreign substances.

We would naturally expect that the pressure on the lower end of the bulb would considerably change its size, and that a pressure of over a half pound could not continue long without considerably altering the size, volume and accuracy of the thermometer. In the case under discussion the volume of the bulb would be increased by pressure on lower end. Also since the length of the bulb is 25 mm.

and only 4 mm. in diameter it would stand a greater strain before yielding than it would were it any other shape.

Considering it as above, the first reading would naturally be expected to be a mimimun, for as the volume of the bulb is a maximum the mercury stands lowest in the stem, and the readings on subsequent observations would increase until a fairly stationary point is reached, indicating that the bulb has regained its normal volume.

The first reading taken Saturday, November 16th, showed the thermometer to be in error 0.1479°. The second reading taken on the following Wednesday was 0.1528°. The third, taken on the following Saturday, was 0.1540°, and the fourth, taken on Wednesday, November 24th, was 0.1553°. These readings are each the mean of four and five separate observations. They show a gradual increase in the length of the mercury column which is in direct accordance with what was first expected, *i. e.*, that the pressure on the bottom of the bulb would increase the size of the same and which in consequence would lower the mercury column.

The part that seems strange to me, and that I can assign no direct reason for, is the behavior of the seven subsequent readings that were taken extending over a period of three and one-half weeks. The fifth reading shows a slight decrease, and so also does the sixth reading show a decrease compared with the fifth, after which it oscillated, as it were, about a mean of 0.1493°. The greatest deviation above this mean being .0036, and the greatest below .0026 of a degree.

It was found that the position in which the thermometer was kept had no appreciable effect upon its readings.

Graphical Representation of the Law of Falling Bodies.

By F. P. Stauffer.

[Abstract.]

It was shown that by subdividing a right-angled triangle by lines parallel to the hypotenuse and the sides into similar smaller triangles, the following could be graphically represented—the distance traversed each second, the velocity at the end of each second, the effect of gravity each second.

RATES OF COMBUSTION IN LOCOMOTIVE FURNACES. BY R. A. SMART.

The following brief comparisons of the rates of combustion in locomotive and stationary furnaces, based upon data of tests made at the Purdue University Locomotive Testing Plant, will show some of the effects of the heavy duty which the limitations of space and the requirements of portability impose upon locomotive boilers.

In stationary boiler plants, the usual rate of combustion is between the limits of 8 to 20 pounds of coal per square foot of grate surface per hour. From the record of the rate of combustion of over half a hundred boilers tested by Geo. H. Barrus, a well known expert, an average of 11.5 pounds per foot of grate was found, which may be taken as representing good practice. Under certain conditions of speed and cut-off, it has been found that the Purdue locomotive, "Schenectady," which is a fair representative of its class, consumes 2,670 pounds of coal per hour, while developing 520 indicated horse power. To consume this quantity of coal economically at the rate given above would require a grate area of 232 square feet. Taking 8 feet as the extreme allowable width, this would give a furnace 29 feet long, which is of course much beyond the limits of available space. As the furnace of the Purdue locomotive has, however, only 17.5 square feet of grate surface, instead of 232, the rate of combustion under the conditions mentioned above reaches the abnormal figure of 153 pounds per square foot per hour.

It has been stated by Isherwood that the evaporative efficiency of horizontal return tubular boilers of ordinary design decreases as the rate of combustion increases, and if this holds in stationary practice it may be taken, in a measure, as applying to locomotive practice. From this it is apparent that where only 17.5 square feet of grate surface are provided to consume a quantity of coal requiring over 200 square feet for economical combustion, thereby raising the rate of combustion from 11.5 to 153 pounds per square foot, the evaporative efficiency will necessarily be low.

This extraordinary rapidity of combustion is still more striking when compared with the conditions existing in an open fireplace. For instance, the rate of combustion in an ordinary parlor grate is about 4 pounds per hour to the square foot. At this rate it would require a grate equal in area to that of a room 26 feet square to consume the coal burned during the tests mentioned.

Other comparisons may be made as follows: Stationary boilers are usually allowed about 12 square feet of heating surface per horse power developed, while the total heating surface of "Schenectady," about 1,200 square feet, allows, under

ordinary conditions, 4 square feet to the horse power, and under extreme conditions, but 2 square feet.

The draft in a stationary plant having a chimney 50 feet high is less than 0.5 of an inch of water. The locomotive frequently runs under a draft as heavy as six inches, making it necessary for the fireman to keep a very thick fire on the grates.

With such great differences existing between the conditions apparently required by economy and those actually found in locomotive practice, it would be expected that the evaporative efficiency of the latter would be small by comparison. It is interesting to note, however, that in spite of the disadvantages under which the locomotive labors, its evaporation is seldom less than 50% of the best evaporation given by stationary plants.

The Influence of Heat, the Electric Current and Magnetism Upon Young's Modulus. Mary Chilton Noyes.

A series of experiments were carried out in the physical laboratory of Western Reserve University to determine the effects of heat, of an electric current and of magnetism upon the elasticity of piano wire, and of copper and silver wire. The wires were heated by means of an electric current from a storage battery, the current sometimes going through a magnetizing helix surrounding the wires, sometimes through a non-inductive coil, and sometimes through the wires themselves. The methods of heating were used in different order with different pieces of wire, in order to detect, if possible, any temporary or permanent effect which was not due to the heat, but no such effect could be found.

The thermal co-efficient of elasticity for the piano wire was found to be 4.6% for 100°. For the silver wire it was about 8% and for the two specimens of copper wire tested 13% and 7%. The permanent change in elasticity produced by repeatedly heating the wires was from one to two per cent.

With the silver and copper wires the effect of heat upon the elastic limit was determined. The limit was found to decrease quite rapidly and regularly as the temperature was raised. The two specimens of copper wire tested were found to give quite different results for the thermal co-efficient of elasticity, the co-efficient of expansion and the co-efficient of decrease in the elastic limit with rise of temperature.

The Surface Tension of Liquids. By Arthur L. Foley.

Although many methods of measuring the surface tension of liquids have been proposed and used, its absolute value is not known in a single instance. Various experimenters by various methods have obtained various results; these results differing from one another in many cases by as much as fifty per cent. For instance, Quincke, for the surface tension of water at 0°C, has obtained the following results by the methods named:

1. By measuring the rise of water at a vertical wall he obtained 8.7 mgm. per mm.
2. By measuring the axis of a bubble of air in the interior of a liquid, 8.2 mgm.
3. By the rise of water in capillary tubes, 7.6 mgm.
4. By measuring the size of falling drops, 6.5 mgm.

These results show an average variation of about ten per cent., and a difference between the first and last of thirty-four per cent. Many other methods have been used, but the results obtained are not more consistent than those given above. The method generally used, and that which probably gives as consistent results as any yet proposed, is the method of capillary tubes. But even if we restrict ourselves to this one method, and to the results obtained by a single experimenter, we find that they differ considerably. Let us again note the results obtained by Quincke—than whom there is no better authority upon this subject. In Wiedeman's Annalen, April, 1894, Quincke gives values ranging from 7.69 to 8.16 mgm. per mm. for different sizes of tubes made from the same specimen of Jena glass; and values from 7.8 to 8.1 for English flint glass. In the October number of the Annalen, 1894, Volkmann gives as widely different results for various specimens of glass. The age of the tube is found to influence the height to which the water rises in it. So it would seem that a better method of measuring the surface tension of liquids is greatly to be desired.

In the "Philosophical Magazine" of November, 1893, Mr. T. Proctor Hall describes some "New Methods of Measuring the Surface Tension of Liquids." Two years ago at the suggestion of Professor Michelson of the Chicago University, I undertook to repeat and to extend the investigation. In the present article, I shall confine myself to a brief statement of the results obtained by using Mr. Hall's method *c*, the maximum-weight method.[1]

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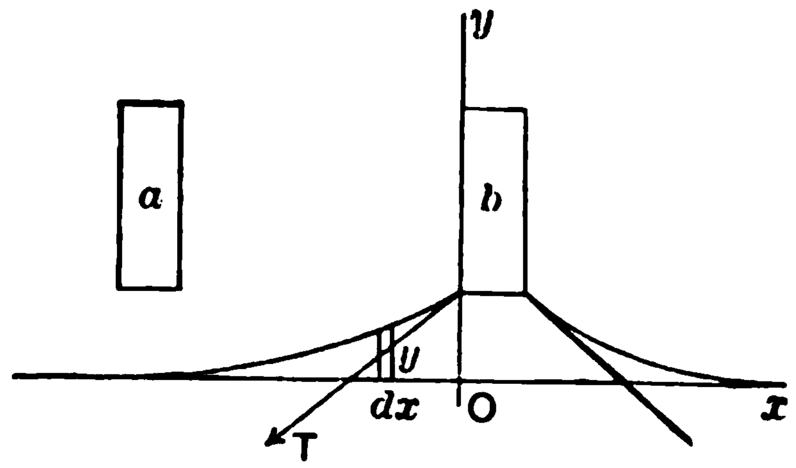
[1] Philosophical Magazine, November, 1893, p. 402.

Fig 1



Let a (Fig. 1) be an end face of a rectangular parallelopiped suspended from one arm of a balance, with its lower face horizontal, and therefore parallel to the liquid surface OX. Call w' the weight of the frame (block) in this position. Lower the frame until it touches the liquid, and bring it again to the first position, as in b. The weight of the frame is now increased by the weight of the liquid raised above the level surface. As the frame is raised, the weight increases for a time then suddenly decreases, passing through a distinct maximum. Call w'' the total maximum weight. The net maximum weight is

$$w = w'' - w' = 2T\sin\alpha + \rho t y, \tag{1}$$

where T = the surface tension in grams per centimeter;

α = the angle between the X-axis and the tangent to the liquid surface at the edge of the frame;

t = the thickness of the frame;

ρ = the density of the liquid;

y = the height of the frame above the liquid surface;

l = the length of the frame, one centimeter.

Also,

$$T\sin\alpha = \rho\int_{-x}^{0} y\,dx, \tag{2}$$

$$\frac{dx}{d\alpha} = \frac{T\cos\alpha}{\rho y}.$$

Placing $c^2 = \frac{T}{\rho}$, and remembering that $\frac{dy}{dx} = \tan\alpha$,

$$\frac{dy}{d\alpha} = \frac{c^2\sin\alpha}{y};$$

$$y^2 = -2c^2\cos\alpha + k.$$

When $y = 0$, $\alpha = 0$, and $k = 2c^2$.

$$\therefore y = 2c\sqrt{\frac{1-\cos\alpha}{2}} = 2c\sin\frac{\alpha}{2}$$

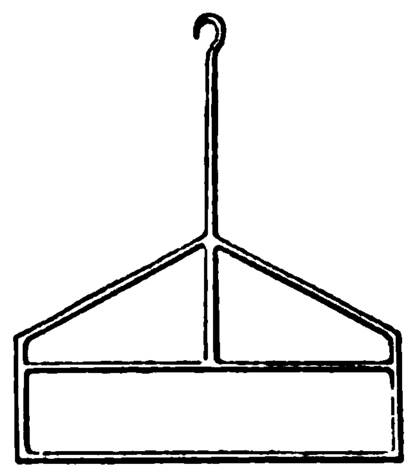
4

$$\cos\frac{a}{2}=\sqrt{\frac{4c^2-y^2}{4c^2}}; \tag{4}$$

$$\cos a=\frac{2c^2-y^2}{2c^2}. \tag{5}$$

Let us now suppose that the frame has vertical legs (as in Fig. 2) extending downward into the liquid. Let l be the length between the legs.

Fig 2



Equation (1) becomes

$$\begin{aligned} w &= 2T(l-t)\sin a + ptly, \\ &= 2pc^2(l-t)\sin a + 2ltpc\sin\frac{a}{2}. \end{aligned} \tag{6}$$

When w is a maximum, $\frac{dw}{da}=o$. Let t be very small compared with l, then

$$2c\cos a + t\cos\frac{a}{2} = o.$$

Eliminating a by (4) and (5), and inserting the value of c,

$$y=\sqrt{\frac{2T}{p}-\frac{t^2}{8}-t\sqrt{\frac{64}{t^2}+\frac{2p}{T}}}.$$

When t is small, a near approximation is

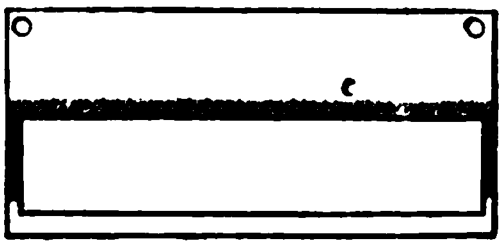
$$y=\sqrt{\frac{2T}{p}}. \tag{7}$$

Supplying this value of y in (6), and solving for T,

$$T=\frac{w}{2(l-t)}+\frac{pl^2t^2}{4(l-t)^2}-\frac{lt}{4(l-t)^2}\sqrt{p^2l^2t^2+4w(l-t)p}. \tag{8}$$

Table II gives the value of T calculated by the above formula for mica frames varying in thickness from 0.0013 cm. to 0.02067 cm.

Mr. Hall in his investigation used glass frames (made of cylindrical glass rods) of the shape indicated in Fig. 3. He deduced for them equations correspond-

Fig 3 

ing to (6), (7) and (8). He admits, however, that these equations are so complicated as to be almost unmanageable, and that the correction is obtained more easily by determining the constants of a frame by using frames of different length and of the same diameter, and again of the same length but of different diameters. It is very difficult indeed to make such frames, and to use them after they are made.

The chief objections to glass frames may be summed up as follows:

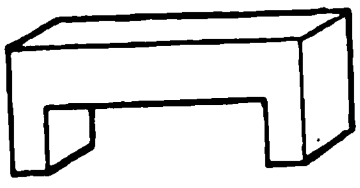
The value of y, and hence the correction that must be applied to the maximum weight in order to obtain the true film weight which measures the tension, depends in a very complicated way upon the diameters of the rods of the frame.

This correction forms a considerable part of the total maximum weight (see Table I.). Frames can not be made sufficiently rigid and less than 0.03 cm. in diameter. Hence the correction is at least ten per cent. of the whole.

The frames are difficult to make and they require delicate handling at every stage.

With cylindrical end rods the actual length of the film surface is uncertain.

It occurred to me that these troublesome corrections and inaccuracies might be partially avoided by using a different kind of frame. After experimenting with frames of various materials, among which I may mention thin sheet glass, platinum, aluminum and mica, I found that the latter offered decided advantages over glass. The general shape of the mica frame is given in Fig. 4. The frame is supported by a forked glass stem, and the method of using is exactly as with a glass frame.

Fig 4 

My first frames were made by cutting the mica sheet as it lay under a steel rule upon a piece of plate glass. I afterwards had made two heavy steel plates of the exact shape of the frame desired. The inner surface of each plate was ground plane with emery dust upon plate glass. A sheet of mica was clamped between them and cut to their dimensions. The advantages of frames made in this way are:

The steel plates are accurately ground; the frames are correspondingly regular.

The mica does not split along the cut edge.

The edge is of the same thickness as the plate itself; there is no bur. Very thin frames are easily made, but it is difficult to work with them when they are much less than 0.002 cm. thick.

A difficulty experienced with the mica frame, as also with those of platinum and aluminum, is that the fluid does not readily and equally wet all portions of the surface. It has a tendency to collect in drops, rendering the after-weighing uncertain. This difficulty was entirely overcome by roughing the surface (darkened in Fig. 4) of the plate near the edge by rubbing very lightly with the finest French emery paper. Both weights could then be taken again and again with a variation of only a few hundredths of a milligram.

The advantages claimed for the mica frame are as follows:

1. They are easily made, and do not require careful handling.

2. They are of even thickness, with straight edges and square corners. Hence the film length is not so uncertain as with glass frames.

3. They can be made less than one-tenth of the thickness of a glass frame, reducing the correction correspondingly. Table I gives the relative corrections for glass and mica frames, obtained by determining the maximum weight for a soap solution, and then weighing the film itself. The film weight divided by twice the length of the frame gives the surface-tension. But with many liquids it is impossible to obtain the film weight, as the film breaks immediately after it is formed. The maximum weight can be determined in almost every case, and the film weight by correction. It is evident that a slight error in the value of this correction will be lessened by reducing the total correction, as is done by using the mica frame.

TABLE I.

Kind of Frame.	l	t	w	Film Weight.	Per cent. Difference.
Glass	6.346	0.0405	0.39226	0.34100	15
Glass	7.584	0.0510	0.48283	0.40302	19
Glass	10.163	0.0620	0.65420	0.53700	21
Glass	7.475	0.0920	0.52480	0.39660	32
Mica	6.012	0.0030	0.31202	0.30697	1.6
Mica	5.301	0.0051	0.27776	0.27092	2.5
Mica	5.140	0.0079	0.27222	0.26260	3.7

A fresh solution was used in the last three measurements.

4. The correction varies directly as the thickness of the frame, Fig. 5. Observations with two frames of varying thickness are sufficient to determine the actual film weight and hence the tension.

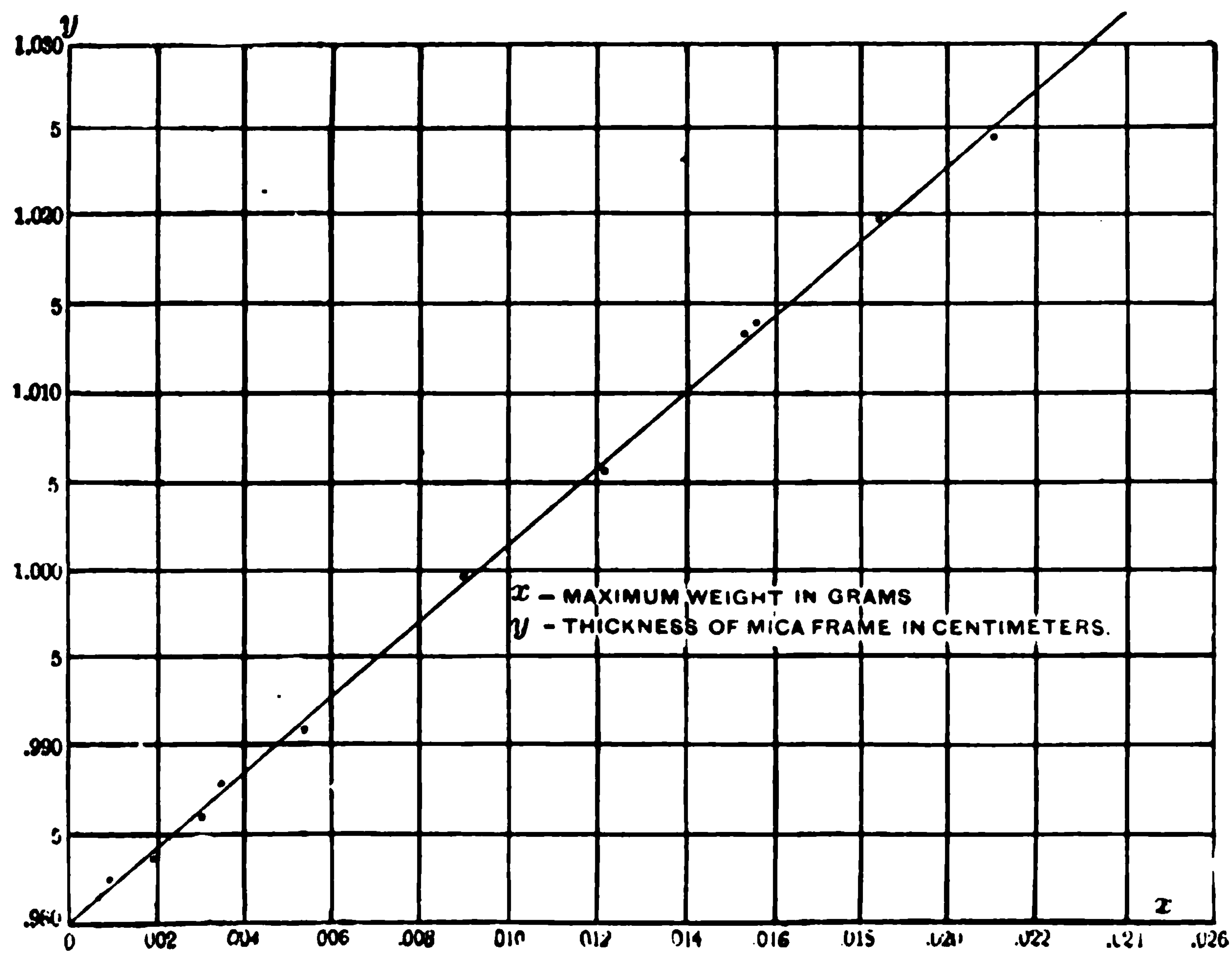


Fig 5

5. In the case of thin frames the tension can be determined at once from the maximum weight uncorrected, with results that vary less than do those obtained by the method of capillary tubes. For example, compare Table II with Table III, the latter giving selected results obtained by Quincke by the capillary tube method.[1]

TABLE II.

t	w	T by formula. $T=\frac{w}{2l}$	T by equation (8)	Temperature of Water.
0.00130 cm.	0.98260 g.	0.07396	0.07365	20°.7 C.
0.00190	0.98420	0.07408	0.07374	20°.7
0.00352	0.98791	0.07437	0.07372	20°.7
0.00516	0.99094	0.07458	0.07365	20°.7
0.00928	0.99991	0.07527	0.07352	20°.8
0.01206	1.00592	0.07572	0.07355	20°.8
0.01536	1.01358	0.07630	0.07345	20°.9
0.01828	1.01973	0.07676	0.07339	21°.0
0.02067	1.02468	0.07713	0.07332	21°.0

TABLE III.

(TEMPERATURE 18 .)

Kind of glass.	Diameter of tube.	Age of tube.	T
Common Jena glass.............	0.5832	0 hr.	0.07528
Common Jena glass.............	0.5851	24 hrs.	0.07336
English flint glass...............	0.6390	2 mos.	0.07490
English flint glass...............	0.5740	0 hr.	0.07411
Fusible (soft) Jena glass.........	0.6440	0 hr.	0.07258
Fusible (soft) Jena glass.........	0.9106	12 hrs.	0.07480

6. As y and t are small, a small error in the assumed value of ρ will not appreciably affect the calculated value of T, Eq. (6).

y being small, the film is much narrower than with a glass frame. Therefore there is less temperature change due to evaporation from the film surface and less absorption of gases and impurities from the air.

[1] Weidemann's Annalen, No. 5, 1894, p. 14.

7. The equations for w and y are not so complex that they can not be used. In Table II are given the values of T deduced by formula (8). It will be noted that the last frame is about sixteen times as thick as the first, yet the greatest difference in these values is but a little more than one part in two hundred. Of the results for the first four frames, the greatest difference is one part in seven thousand. The thicker frames can not be expected to give such consistent results, as the water tends to creep in between the thin layers of which the mica sheet is made up.

THE TEMPERATURE COEFFICIENT.

Previous determinations of the temperature coefficient of surface tension give results not more consistent than the values obtained for the tension itself. Brunner gives the coefficient as .14 dynes per degree, and Merian as .253 dynes. The latter result is almost double the former. Other observers give intermediate values. In view of these differences, I concluded to make a determination of the temperature coefficient by the mica frame maximum weight method. This investigation is not yet completed, so I shall not go into detail.

I am using a Troemner balance, No. 5, easily sensitive to one one-hundredth milligram. The arrangement of the balance and box or closet is very much the same as in Hall's experiment. Inside the wooden box I have a double-walled tin box, open on the side next the glass door. The space between the walls of the tin vessel (the walls being about two inches apart) may be filled with a bath to regulate the temperature of the enclosure. This temperature is obtained by reading three thermometers, placed in different positions. A rotary fan is used to equalize the temperature throughout the enclosure. It is arranged so that the water whose coefficient is to be determined is siphoned in and out of the vessel inside, without opening the door or disturbing the balance.

I have tried four methods of regulating the temperature of the enclosure. A current of air from a blower giving a very constant pressure was passed through an iron pipe heated by from one to a dozen Bunsen burners, and then through the tin box. By varying the air supply and the number of burners, a fairly constant temperature could be maintained. But I was not able to raise it above 50°. I next tried a water bath, the water being heated in a tube outside, but connected with the box—somewhat upon the principle of an incubator. I could easily maintain any desired temperature between 0° and 70°. But for higher temperatures I found that the convective circulation of the water was too slow to prevent the water in the tube from boiling. I substituted oil for water, but I was not able to extend my observations above 80°.

By far the most satisfactory method is to fill in between the walls of the tin box with mineral wool, and to use wire coils and an electric current to heat the enclosure.

In the earlier part of my work I used distilled water from the Chemical Laboratory. Subsequent tests showed that it contained considerable organic matter. I am now using water which has been distilled three times in glass; once with permanganate of potassium to remove organic matter. My observations range from 0° to 80°, and cover a period of four months.

Briefly, my conclusions are as follows:

Between 0° and 80° the temperature coefficient curve is concave toward the x axis, when we use tensions as ordinates and temperatures as abscissas. This coefficient increases with the temperature, its value being about .17 dynes.

The formula usually used to represent the tension (T) at any temperature (t°) is

$$T_{t^\circ} = T_0 - .14\, t^\circ.$$

I find that the tension can not be expressed as a linear equation, and that .14 dynes is too low for the average temperature coefficient.

Much of my work so far has been toward perfecting the method and my apparatus. I am now making some observations, using exceedingly thin mica frames, and standardized thermometers reading to one one-hundredth of a degree. For temperatures below 0° I shall use the method described by Messrs. Humphreys and Mohler in the "Physical Review," March-April, 1895. I shall endeavor to extend my observations above 100° by using the capillary tube method, the water and tubes being enclosed in an air-tight plate glass box and under whatever pressure is necessary to maintain the desired temperature without boiling the water.

PHYSICAL LABORATORY, INDIANA UNIVERSITY, December, 1895.

STRAINS IN STEAM MACHINERY. BY W. F. M. GOSS.

Masses of metal when of considerable strength and weight would appear to be proof against distortion under the influence of any force which may be brought to bear upon them. We think of the *strength* of metals, but it is not often that we consider their elastic property, yet, physically speaking, nothing, probably, is more elastic than steel. A piano wire, if tightly strung, increases its length, and if loosened again it contracts. Within certain limits it behaves precisely like a spring. When force is applied it stretches, and when the force is withdrawn it

recovers itself again. If the force is considerable, change in the length of the wire may be easily observed; with a less force it will not be so apparent but still measurable, and, finally logic requires us to believe that if the force applied and withdrawn is infinitely small, there will still be a change in the length of the wire acted upon.

That which is true of a wire is equally true of all masses of metal of whatever proportion. A cube of steel may resist an enormous load tending to crush it, and yet the application of a slight force effects a decrease in its height. The change in form under light loads is certainly small, but actual, nevertheless. That which is true of steel is, in a general sense, equally true of wrought and cast irons, and, in fact, metals of every sort.

The machine designer, therefore, can not, as some suppose, make the several parts of his machine so strong that they will remain fixed in form, but he must choose rather so to distribute the metal with reference to the stresses to be transmitted, that the change in form which is sure to occur, will not interfere with the action of the proposed machine.

Some years ago the writer became interested in tests involving a measurement of the strain, that is the change in form, of various parts of steam engines, parts supposedly invariable, while the engines were being worked under load. The apparatus employed consisted of a fine micrometer screw mounted upon a frame work wholly apart from the engine and having no connection with it, but so arranged that the screw could be brought in contact with the part to be examined. In making observations, one terminal wire from a telephone receiver was attached to the part of the engine which was under examination, and the other terminal from the telephone to the micrometer; the observer placed the telephone to his ear, and slowly screwed the micrometer in towards the desired point on the engine. If the part of the engine in question was in vibration it first touched the point of the advancing screw for an instant for each oscillation, the contact being made manifest to the observer by a sharp click in the telephone as the circuit was made and broken again. This fixed one boundary by which the amplitude of the vibration was to be determined. Next the micrometer was advanced towards the engine until the screw did not break contact with the machines, a condition which was denoted by a cessation of sound in the telephone, while for all intermediate points the clicking in the receiver kept time with the revolutions of the engine. It was assumed that this last position of the micrometer marked the other boundary of the vibration. The difference of the two readings of the micrometer gave the amplitude of the vibrations, or the extent of the motion in the part examined. A large number of readings from several parts of two engines

in the Laboratory of Purdue University were taken by Mr. Adam Herzog, B. M. E., a summary of which is as follows:

First, measurements were taken from a 15 x 24 Corliss engine; this machine has unusually massive parts, the frame being a heavy girder, and the whole being mounted in an excellent manner upon a deep foundation. Observations were made while the engine was developing only 35 horse-power with an initial steam pressure of 80 pounds. The head end of the cylinder was found to move in a horizontal direction with every revolution of the engine, a distance of 0.009 of an inch; the frame over the guides moved in a vertical direction 0.014 of an inch, and the pillow block castings in a horizontal direction 0.030 inches.

Secondly, measurements from a 14 x 16 engine, having a modification of the box-bed, mounted upon a substantial foundation, capped by a single stone of massive size. The details of the engine are heavy and well designed. Its center line, however, is considerably above the line of resistance offered by the bed. Observations were taken during a time when the engine was running under an initial pressure of only 40 pounds and while developing only 14 horse-power, which is less than half its rated power. The head end of the cylinder was found to move horizontally 0.018″, and the top of the cylinder at the flange on the crank end to move vertically 0.022″.

These vibrations, while taking place with every stroke of the engines, would not ordinarily have been detected with the eye, and were not accompanied by any shock or other manifestation which would indicate their presence. The measurements will serve to show to what extent the heavy fixed parts of well-designed machines may move under the influence of the forces which they are designed to resist, and they emphasize the necessity for a distribution of the metal which will give strength in direct line with the stresses to be transmitted.

Viscosity of a Polarized Dielectric. By A. Wilmer Duff.

[Abstract.]

Very few observations of mechanical actions produced in liquid dielectrics by electro-static stress have been made. Faraday found that fibres of silk in the liquid set themselves along the lines of force. Quincke thought he had detected an alteration of volume, but his results have been doubted. König tried to find a variation of viscosity by finding the rate of flow through a capillary tube placed between charged plates, but failed. A limit was set to the accuracy of his method by the difficulty of maintaining the tube at a constant temperature.

The author has sought a variation of viscosity by observing the rate of descent of small drops of mercury through castor oil, which served as the dielectric n a plate condenser. The condenser consisted of a tall, glass tank, the middle part of which served as a condenser, tin-foil being glued to the middle half of the outsides of the glass plates. To eliminate temperature effects the ratio of the time of descent through the condenser part of the tank to the time of descent through the non-condenser part, the condenser being uncharged, was compared with the ratio similarly obtained when the condenser was charged. In this way any change of temperature affecting the whole tank may be eliminated. To further eliminate any variation affecting different parts of the tank unequally, a long series of readings was taken with the condenser alternately charged and uncharged; and each ratio obtained with the condenser charged was compared with the mean of the adjacent ratios obtained with the condenser uncharged. The experiment was performed in a cellar of fairly constant temperature, temperative effects being thus almost perfectly eliminated; long series of readings made as described showed invariable increases of viscosity on the application of electro-static stress. The variation of viscosity seemed to be dependent rather on a non-uniform or varying electro-static field than on a steady field. Castor oil and glycerine showed an increase of viscosity.

As the above method could only be applied to very viscous liquids, the author also constructed an analogous apparatus on the capillary tube principle suitable for mobile liquids. It consisted of a capillary tube placed vertically between condenser plates, and connected above to a large tube with four constrictions in it dividing it off into three compartments. The times of emptying of the compartments by flow through the capillary tube were observed, the condenser being first uncharged during the emptying of the middle chamber and then charged. If the ratio of the time of emptying of the middle chamber to the sum of the times of emptying of the other two be taken, the condenser being uncharged, and compared with the ratio similarly obtained, the condenser being charged, a method free from temperature effects is again obtained for detecting a viscosity variation. In this way it was found that under a varying electro-static field, carbon di-sulphide showed an increase of viscosity and paraffine oil a decrease.

The above methods are being applied to other liquids, and a determination of the law of variation of the effect discovered under varying strengths of electrostatic field will be made later.

On the Alternating Current Dynamo. By W. E. Goldsborough.

Consider the case of a simple alternator having but one armature coil that rotates in a magnetic field of uniform intensity about an axis at right angles to the direction of the lines of force. If successive instants of time during one revolution of the coil are counted from the instant that the coil passes a line drawn through its axis of rotation and perpendicular to both the axis of rotation and the direction of the magnetic flux, the value of the induction piercing the coil at any instant during one cycle is expressed by the equation

$$N = N_{max} \cos wt, \tag{1}$$

in which N_{max} equals that portion of the flux that passes through the coil at the instant the plane of the coil is at right angles to the direction of the lines of force and w represents its angular velocity. The instantaneous value of the E. M. F. generated in the coil will be, by Faraday's law

$$e = -\frac{dN}{dt} = w\, N_{max} \sin wt,$$

$$= E \sin wt \tag{2}$$

since its maximum value

$$E = w\, N_{max} \tag{3}$$

If the coil is closed through a circuit of resistance R_1, inductance L_1 and capacity C_1, the resistance and inductance of the coil itself being R and L respectively a current i will begin to circulate and we can write the equation of E. M. Fs. of the circuit in the form

$$e = (R + R_1)\, i + (L + L_1)\frac{di}{dt} + \int \frac{idt}{C_1}.$$

From this expression we can derive the equation of the current in terms of the constants of the circuit and the maximum value of the E. M. F. developed in the coil and obtain

$$i = \frac{E}{\sqrt{[R + R_1]^2 + [\frac{1}{C_1 w} - (L + L_1)w]^2}}$$

$$\sin\left\{ wt - \tan^{-1}\left[\frac{1}{C_1 w (R + R_1)} - \frac{(L + L_1)w}{R + R_1}\right]\right\} \tag{4}$$

which expresses the instantaneous value of i as soon as a condition of cyclic stability has been attained.

Equations (1), (2) and (4) are the general equations that cover the working of alternating current dynamos; they have been subjected to graphical analysis,

the results of which are exhibited in the figure opposite page 80, and are discussed in the following paragraphs:

Suppose a circuit in which the inductance is zero, the capacity infinite and the resistance variable, to be subjected to the influence of a simple harmonic E. M. F. that is generated by an alternator having a constant armature inductance for all values of armature current, a constant field excitation and a constant speed. Under these conditions the virtual value of the E. M. F. at the brushes of the alternator just before the circuit is closed will be,—

$$\overline{E} = w\, N_{max} \div \sqrt{2}\ ; \tag{5}$$

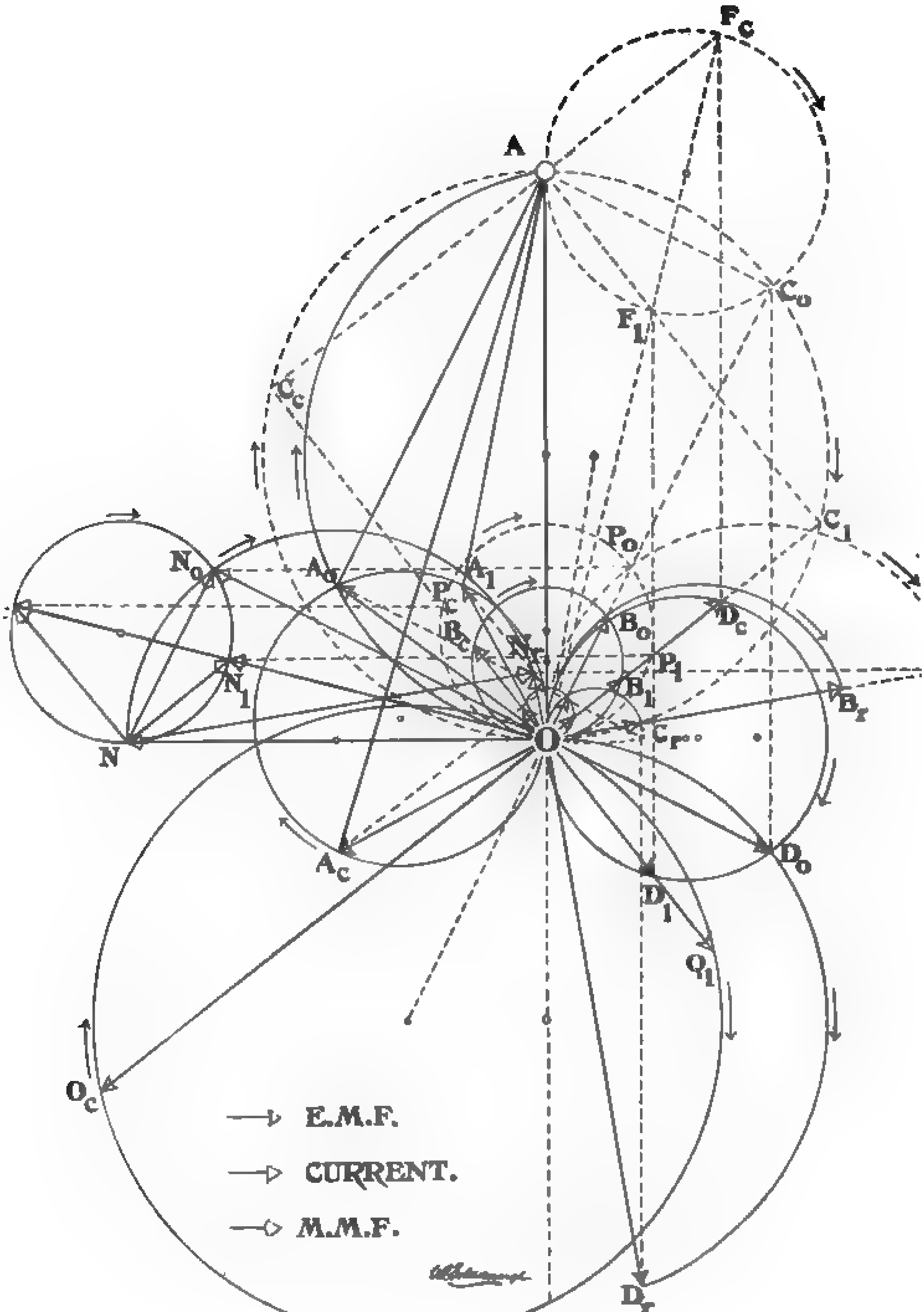
which is represented by the vector OA in the figure. The vector ON is laid off at right angles to OA to represent the value of the M. M. F. producing N_{max}. It is drawn 90° in advance of the E. M. F. it induces in accordance with the relation exhibited in equations (1) and (2). At the time of closing the circuit suppose the external variable non-inductive resistance to have a value R_1, and that the constant armature resistance has a value R and the constant armature inductance a value L. Then the equation of the current will assume the form:

$$i = \frac{E}{\sqrt{(R + R_1)^2 + L^2 w^2}} \sin\left[wt - \tan^{-1}\frac{Lw}{R + R_1}\right] \tag{6}$$

and its virtual value—

$$\overline{I} = \frac{\overline{E}}{\sqrt{(R + R_1)^2 + L^2 w^2}} \tag{7}$$

which we can represent by the vector OB_0 lagging $\tan^{-1}\dfrac{Lw}{R + R_1}$ degrees behind OA. This armature current will react upon the magnetizing forces due to the constant field excitation, and by virtue of the inductance of the armature will produce an M. M. F. in phase with itself which is represented by the vector NN_0, drawn parallel to the current vector from the positive extremity of ON. This armature M. M. F. sets up a cyclic magnetization developing a counter E. M. F. OD_0 lagging 90° degrees behind the current, and there is a loss of effective E. M. F. due to the armature resistance that is shown by the short E. M. F. vector in phase with OB_0, therefore the total loss of E. M. F. in the armature will be the resultant of these two vectors or OA_0. The effective E. M. F. that overcomes the resistance of the non-inductive external circuit will be the vector A_0A, since it completes the E. M. F. triangle on OA and is in phase with the current



E.M.F.
CURRENT.
M.M.F.

OB_0. The total effective E. M. F (OC_0) that overcomes the total ohmic resistance ($R + R_1$) of the circuit, is due to the cyclic magnetization set up by the M. M. F. vector ON_0. ON_0 is the resultant of ON and NN_0 and as shown by the geometry of the figure it is 90° in advance of the current, and therefore of A_0A, as it should be. The projection of NN_0 on ON is the component of the armature M. M. F. that acts against the field magnetization, *i. e.*, it is *a measure of the armature reaction.* The projection of NN_0 on OA is likewise a measure of the cross-magnetizing action of the armature.

Having constructed the initial diagram we can now follow out what takes place when the resistance of the external circuit is varied. Suppose R_1 is reduced to a value R_r. The current vector head B_0 will move out along the semicircle OB_cB_r until equilibrium is again established in the circuit by the current reaching its maximum possible value under the new conditions.* The vectors OA and ON retaining their positions, all the other vectors involved will reach their final values corresponding to the new current by following the arcs of the circles passing through their positive extremities to the positions designated by the common subscript letter (r). The correctness of the variations indicated can be readily verified by an inspection of the geometry of the figure in connection with equation (7).

In the present case R_1 has been reduced to zero; in other words the subscripts (r) indicate what takes place when a machine whose armature inductance is large, as well as constant, is short circuited. A_0 moves up to A, and the E. M. F. at the brushes is zero. The current assumes an angle of lag of almost 90° behind the total internal armature E. M. F. OA, the *armature reaction* almost counterbalances the M.M.F. of the fields, and the resultant M. M. F. ON_r is just sufficient to develop the E. M. F. OC_r that overcomes the resistance of the armature.

Returning to the initial conditions, suppose we increase the value of L_1 from zero to some value L_1, *i. e.*, suppose we introduce inductance into the external circuit. The virtual value of the current will then be expressed by the equation

$$I = \frac{E}{\sqrt{(R + R_1)^2 + (L + L_1)^2 \omega^2}} \qquad (8)$$

and it will lag behind the internal E. M. F. E or OA, by an angle

* See Bedell and Crehore's Alternating Currents, page 223.

$$\phi = \tan^{-1}\left(\frac{L + L_1}{R + R_1} w\right). \tag{9}$$

Referring to the figure, the new positions assumed by the variable vectors, owing to the introduction of L_1, are designated by the subscript letter (l). The current will decrease and its vector head move along the circle $OB_cB_0B_1O$ until a state of equilibrium exists between the forces involved. The E. M. F. that overcomes the resistance and inductance of the armature will decrease also and move to the position OA_1, its vector head following the circle $OA_cA_0A_1O$, and the E. M. F. at the collector rings will first decrease and then increase to a final value A_1A. The introduction of inductance into the external circuit brings the E. M. F. at the collector rings and the total internal E. M. F. (OA) more nearly into phase; it, however, causes a lag angle F_1OB_1 to be introduced between the collector E. M. F. and the current. The inductance E. M. F. of the armature decreases along the circle $OD_cD_0D_1O$ to a value OD_1 and the inductance E. M. F. of the external circuit increases from zero along the circle YQ_cOQ_1Y to a value OQ_1. The resultant M. M. F. will be OX_1, and it is seen that while the armature reaction has remained very nearly constant the cross-magnetizing effect has been reduced about 50 per cent.

From our initial conditions as indicated by the subscript letter (o) we can also study the effects produced by the introduction of capacity into the external circuit. If the value of C_1 is reduced from infinity to some value C_c, the virtual value of the current will change to

$$\overline{I} = \frac{\overline{E}}{\sqrt{(R + R_1)^2 + \left(\frac{1}{C_c w} - Lw\right)^2}} \tag{10}$$

and the angle between OA and the current will have a value

$$\phi = \tan^{-1}\left[\frac{1}{(R + R_1)\,C_c w} - \frac{Lw}{(R + R_1)}\right] \tag{11}$$

In consequence of this change the current vector will assume the position OB_c and the other variable vectors will move to their corresponding positions shown by the subscript letter (c). The current in its new position is not only in advance of the E. M. F. (A_cO) at the brushes, but is also in advance of the E. M. F. OA, since it has moved from B_0 to a maximum value when passing OA, and then decreased in value.[1]

1. See Bedell and Crehore's Alternating Currents, p. 297.

The collector E. M. F., on the other hand, steadily increases as the capacity decreases till it reaches a value A_cA much greater than the open circuit E. M. F. of the machine. A resonant effect comes into play here after the capacity of the line neutralizes the inductance of the armature that is very well illustrated by the figure: the line A_cA will be a maximum when it passes from A through the center of the circle $OA_cA_0A_1O$, and will represent the greatest difference of potential that can possibly exist between the brushes so long as R and R_1 remain unchanged in value. This rise in potential is due to the current being in *advance* of the vector OA, for the position of the armature M. M. F. vector is also advanced, and NN_c increases the total flux in the air-gap instead of diminishing it. The cross-magnetizing action of the armature, however, remains approximately the same.

The introduction of capacity into the line causes the inductance E. M. F. of the armature to move to the position D_c, and the reactance E. M. F. of the external circuit to decrease through zero and then increasing, assume a position Q_cO, considerably in advance of the collector E. M. F., and 90° in advance of the current OB_c.

The arrows indicate the relative direction of motion of the vectors as the resistance is varied from infinity to zero, or as the reactance is carried from zero capacity to an infinite inductance.

By following out a similar line of constructions the effects produced by variations of the armature inductance can be studied, and by successfully varying the resistance, inductance, capacity and frequency constants, and constructing corresponding diagrams, a large variety of problems involving the simultaneous variation of several terms can be successfully treated.

A Method of Measuring Permeability. By A. Wilmer Duff.

[Abstract.]

The most common method of measuring the permeability of iron, or the ratio in which the presence of iron strengthens the magnetic field, is to make a ring of the specimen, cover it with two layers of wire, one connected with a source of current to magnetize the ring, the other with a ballistic galvanometer to measure the quantity of electricity induced in this secondary coil by making or breaking the primary current. The galvanometer is calibrated by means of a straight calibrating coil consisting of a non-magnetic core similarly wound with a primary

and secondary. Then from the various dimensions of the ring and the calibrating coil as regards number of turns of the primary and secondary, cross-section and length of core, intensity of primary currents and throws of the galvanometer, the permeability of the specimen can be calculated.

The objections to the above method are the tediousness of observing the constants (about a dozen in all) and making the calculation therefrom, and, further, the inaccuracies involved in assuming the areas of windings and core to be the same, in neglecting the difference in closeness of winding between the inside and outside of the ring, etc.

For the last two years the author has recommended the following method to his students. An exact non-magnetic copy of the ring specimen is made in the form of a plaster of Paris cast therefrom. This cast is wound precisely similarly to the iron ring. The permeability is then simply the ratio of the throws given by the iron ring and the plaster of Paris ring on making or breaking equal currents in the primaries. The calculations are thus greatly simplified and the inaccuracies involved in the above mentioned assumptions are greatly reduced and can be completely eliminated by winding the primaries and secondaries in alternate turns on the core. It is not claimed that by this method the galvanometer is more exactly calibrated, but it is calibrated under the exact conditions under which the actual measurements on the specimen of iron are made. It is calibrated, in fact, by the actual windings on the ring specimen, the iron core being replaced by a non-magnetic core.

With a view to testing the sum total of the errors inherent in the ordinary ring method, simultaneous determinations of the permeability of the same specimen were made by the two methods. It was found that the total error involved in the use of the ordinary calibrating coil was often large, amounting in some cases to as much as thirty-eight per cent.

Empirical Formula for the Temperature Variation of Viscosity. By A. Wilmer Duff.

[Abstract.]

A careful determination was made of the viscosity of glycerine between zero and thirty degrees. The method employed depended on Stokes' formula for the rate of descent of a sphere through a viscous liquid. Several different forms of formula have been proposed for the representation of this temperature variation. It was shown that none of these would apply throughout a wide range of

temperature variation. By plotting a curve of the sub-tangent of the viscosity-temperature curve against the temperature, a subsidiary curve was formed which should, in all the types of formula proposed, be a straight line, but which turned out to be a parabola. On determining the constants of the parabolic equation and integrating this to obtain the equation of the viscosity-temperature curve, a formula was deduced which represented the experimental results to within the limits of experimental accuracy. This formula was an exponential one, the exponent being the inverse tangent of a linear function of the temperature. Reasons were given for believing that this would represent the temperature variation of the viscosity of any liquid.

The Effect of Grape-Sugar Upon the Composition of Certain Fat-Producing Bacteria. By Robert E. Lyons.

It has been observed by Dr. E. Cramer* and others† in studies upon the composition of bacteria, that the same micro-organism grown upon Peptom and Grape-sugar Agar-Agar produces in each case different quantities of nitrogenous substances and matter which is soluble in alcohol and ether.

In this same direction Ducleaux‡ demonstrated that yeast cells grown upon a material containing grape-sugar produced fat, while the same yeast grown upon pure nitrogenous material did not produce fat.

To study how grape-sugar affects the quantities formed of nitrogen, ash, fat and matter to be extracted by means of alcohol and ether, three varieties of capsule bacilli were selected:

Pfeiffers' Capsule Bacillus.

Fadenziehender Capsule Bacillus.

No. 28 Capsule Bacillus.

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*Dr. E. Cramer—"Zusammensetzung der Bacterien in ihrer Abhängigkeit von dem Nährmaterial." Arch. für Hygiene—*16*, 151-191.

† Tayosaka-Nishimura—"Zusammensetzung eines Wasserbacillus." Arch. für Hygiene *18*, 318-333.

‡ Ducleaux—"Sur la nutrition interacellulaive." Ann. de l'Institute Pasteur—1889 No. 8, p. 413.

§ Fadenziehender and No. 28 are forms from the water of the River Lahn, near Mosbourg.

The culture medium employed was a neutral 1 per cent. meat extract, agar agar, with the addition of varying quantities of grape-sugar, 1, 5 and 10 per cent., respectively.

The agar was prepared in an autoclave after the method of v. Meyer & Buchner and every care taken in each preparation to obtain as uniform a material as possible.

To control the uniformity of the various preparations, estimations were made from time to time of the solids (105° C.) in the nutrient media, for example:

10 cc. 1 % grape-sugar agar = 0.369 grm. Residue.
10 cc. " " " = 0.383 " "
10 cc. " " " = 0.374 " "

To grow the organisms agar agar plates were inoculated with a fresh bouillon culture, by means of a roll of thin platinum foil and within a moist chamber placed in the thermostat at 37.°5 C.

At the expiration of 48 hours the purity of the culture was controlled and the bacteria-mass carefully removed with a scalpel and dried in a vacuum over sulphuric acid.

Dr. F. Smith (1) maintains that the presence of grape-sugar in the culture medium causes an increased production of gas and acids.

However, when the drying operation was conducted in the apparatus of Arzberger & Zulkowsky, connected with a condenser, the presence of acid in the distillate could not be demonstrated.

The gas production varied, as the amount of sugar, and the odor of ethylic alcohol was alwaye present, but the odor of the fatty acids was never encountered.

That volatile acids are formed during the growth of the cultures, under the conditions given, could not be demonstrated.

The material dried finally at 105° C. was subjected to analysis.

Estimation of ash :
" " Nitrogen (Kjeldahl N$\times$6.25=nitrogenous substances.
" " Ether extract (Soxhelet's app., 48 hours.)
" " Alcohol extract (Soxhelet's app., 90 hours.)

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(1) Dr. F. Smith—"Bedeutung des Zuckers, in Kultur Medien." Centralblatt für Bact. u. Parsit 18, 1-s. 1.

		1 per cent. Grape-sugar Agar Agar.	5 per cent. Grape-sugar Agar Agar.	10 per cent. Grape-sugar Agar Agar.
Pfeiffer	N. Subst.	62.75	58.88	45.88
	Ether Extr.	1.68	3.50	2.67
	Alcohol Extr.	12.17	17.30	29.60
	Ash	7.16	2.97	3.09
	Total	83.76	82.65	81.24
No. 28	N. Subst.	71.81	59.12	46.25
	Ether Extr.	3.32	3.84	2.84
	Alcohol Extr.	11.39	15.91	22.78
	Ash	6.51	3.66	4.18
	Total	93.03	82.53	76.05
Fadenziehender.	N. Subst.	61.05	44.31	33.25
	Ether Extr.	1.75	2.24	1.87
	Alcohol Extr.	18.40	21.80	27.50
	Ash	8.09	4.50	3.02
	Total	89.29	72.85	65.64

On examination of the table it is seen that a constant decrease in nitrogenous substances of the bacteria-mass accompanies the increasing per cent. of sugar in the culture medium.

Whether or not the total nitrogen consists in part of albumen-nitrogen, or in part of extract-nitrogen; and, further, if the extracted nitrogenous substances contain a lower per cent. of nitrogen than the albumen of the bacteria, can not as yet be determined owing to the very small amount of material.

The increase in the quantity of extract matter goes hand in hand with the increasing per cent. of sugar in the agar agar.

For the matter soluble in ether this is true only to five per cent. grape-sugar; at ten per cent. sugar the maximum production of fat seems to have been attained.

In this connection it is interesting to observe the relationship between the ether extract and the ash.

A decrease in the ash and an increase of fat corresponds to five per cent. sugar and to ten per cent., vice versa.

It might seem that the apparent increase in fat was due wholly or in part to the relative decrease in the ash.

It is readily seen that this is not the case by calculating the per cent., excluding the ash; on the contrary, the three forms studied produce more matter soluble in ether and alcohol when they are grown upon media with a high per cent. sugar than when they are grown upon such containing a lower per cent. sugar.

Briefly stated the results of the investigation are:

1. The quantity of nitrogenous material is inversely proportioned to the quantity of sugar present.

2. To a certain limit the increase of sugar is accompanied by a decided increase in the quantity of fat.

At ten per cent. sugar the most favorable conditions for fat production appear to be overstepped.

3. Matter soluble in alcohol increases constantly with the increasing per cent. of sugar.

A New Method for the Preparation of Phenyl-Compounds With Sulphur, Selenium and Tellurium. By Robert E. Lyons.

The very great similarity between the compounds of sulphur, selenium and tellurium was observed by Frederick Woehler and other chemists of his time.

To trace this similarity further I was led to attempt preparing certain bodies to fill up the gaps between the known compounds of the organic radicals, methyl, ethyl and phenyl, with sulphur, selenium and tellurium.

C. Chabrie* gives the results of several years' study of aromatic compounds of selenium prepared after the Friedel-Crafts' reaction, but this method in my hands did not lead to satisfactory results.

On the other hand, the method proposed by Drs. F. Krafft and W. Vorster,† *i. e.*, the replacement of the SO_2 group in the sulfone by sulphur or selenium:

$$C_6H_5.\,SO_2.\,C_6H_5 + S = C_6H_5.\,S.\,C_6H_5 + SO_2.$$

Diphenylsulfone. Diphenylsulfid.

was easily carried out and afforded 60-70 per cent. of the theoretical amount.

As excellent as this method is for the preparation of sulphur and selenium compounds, it was nevertheless found, that the sulfobenzid, even after prolonged heating with powdered tellurium, remained unchanged.

Tellurium dichloride, Te Cl_2, was next prepared in the hope that through its action upon mercury diphenyl, Hg $(C_6H_5)_2$, the diphenyltelluride would be obtained according to the following reaction:

$$C_6H_5.\,Hg.\,C_6H_5 + Te\,Cl_2 = C_6H_5.\,Te.\,C_6H_5 + HgCl_2.$$

* Ann. de Chemie et de Physique. **VI** série t. **XX**, p. 202-286 (1890); also, Compt. rend. **109**, 182 et 568 (1889).

† Berichte der Deutschen Chem. Gesell. 26. 2813.

However, the reaction did not take place according to the above equation, but the tellurium and the mercury combined in the final reaction, with the formation of monochlorbenzene.

$$(C_6 H_5)_2 Hg + Te Cl_2 = 2C_6 H_5 Cl + Hg Te.$$

From this change I was led to expect the formation of the desired body, Diphenyltellurid, by the double decomposition of Diphenyl-mercury, by means of metallic tellurium alone—and the expectation was happily confirmed by experiment.

$$(C_6 H_5) Hg + Te_2 = C_6 H_5 Te C_6 H_5 + Hg Te.$$

If tellurium and mercury-diphenyl in the proportions by weight indicated by the equation be heated together in a sealed tube filled with CO_2 gas, 4–5 hours, at a temperature of 200° Cent., there results a grayish black crystalline mass, saturated with a thick, heavy oil.

This oil, by extraction with ether and purification by rectification, was found to be Diphenyltellurid, 78 per cent. of the theoretical quantity.

Thus I succeeded in preparing the, till then unknown, diphenyltellurid.

The method is a general one.

Dreher and Otto* studied the action of sulphur upon mercury-diphenyl and were of the opinion that diphenyl-sulphide was formed only at a *red heat.*

However, the corresponding sulphides and telsurides may be obtained with the greatest ease by heating mercury-diphenyl with sulphur or selenium to 200° C. under the conditions given.

Camphoric Acid. By W. A. Noyes.

In a paper presented to the Academy last year two acids, which were called cis-campholytic acid and cis-transcampholytic acid were described. The cis-campholytic acid has now been reduced and a dihydro acid obtained from which the α-brom derivative has been prepared. This, on treatment with alcoh lic potash yields the cis-campholytic acid again, thus proving conclusively that the double union in the latter is in the β position.

Xylyllic acid, $C_6 H_3 \begin{cases} CH_3 & 1. \\ CH_3 & 3. \\ CO_2 H & 4. \end{cases}$ has been reduced by means of amyl alcohol and sodium and the α-brom derivative of the hexahydro acid obtained, was prepared. The latter, on treatment with alcoholic potash, does not give either of the

* Berichte der Deutschen Chems., Gesell, 2. 543.

campholytic acids. This furnishes quite conclusive proof that the formula for camphor proposed by Armstrong* is not correct.

The preparation of the acid, $C\,b\,H_8 \left\{ \begin{array}{ll} CH_3 & 1. \\ CO_2\,H & 2. \\ CH_3 & 3.7 \end{array} \right.$ has been undertaken and by a study of its derivatives it is hoped to secure proof of the truth or falsity of Collie's† formula for camphoric acid.

Note on Milk Inspection. By Geo. W. Benton.

The milk supply of cities is becoming a matter of scientific interest. Formerly milk sophistication consisted of skimming or watering or both. More recently various well authenticated rumors of the employment of chemists in the preparation of adulterants, and the marketing of preparations which enables the creamery to substitute foreign fats for milk fats have caused increased attention and greater care in their examination. The inspector, devoid of scientific skill, relies upon the lactoscope, the lactometer, the hydrometer and the Babcock machine, instruments sufficiently accurate and reliable for the cases of skimming and watering for which they were made, but entirely unreliable when taken alone in the detection of the preparations made by chemists for the express purpose of deceiving those using the instruments.

In my two years' experience in the work of milk analysis, abundant evidence of the untrustworthiness of ordinary inspection came to my notice. Besides the watered and skimmed milk, samples of pure cream, common herd and Jersey milk, were passed upon and pronounced suspicious by the ordinary methods in the hands of the inspector. And, finally, it became necessary, in view of the fabrications employed, to do away with such tests, and subject everything to a more searching examination, as the only sure way to get at the truth.

A case in point came under my observation in December, 1892, as follows:

An inspector brought in a sample of milk which, by his testing instruments, gave evidence of being rich, but the appearance, on close examination, was not in strict conformity with the other indications, and he submitted it for analysis. Results attained were as follows, the data taken from my notes made at the time:

A careful physical examination showed the milk to be abnormally thick for milk, but not for cream. A portion, on standing several hours, failed to show a

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* Ber. d. Chem. Ges. (16, 2260.)

† Ibid. 25, 1116.

cream separation, although there was evidence of an oil separation, lacking only the true color of cream. No artificial color had been used.

The further analysis was as follows:

	Per cent.
Sp. G. at 60° C.	1.024
Water, by evaporation	80.30
Solids, by evaporation	19.70
Solids, by the Lactometer (N. Y.)	13.50
Fats, by Feser's Lactoscope	5.00
Fats, by extraction	4.95
Solids, not fat	14.75

By some oversight the ash, if taken, was not recorded. Absence of a record in this instance would indicate that the ash was not abnormal, as it was my invariable custom to take it. No effort was made to determine the nature of the solids not fat, as the purpose of the analysis was not to determine the kind, but the extent of the sophistication, and, at the time, a press of work prevented my taking up the matter from scientific interests.

The microscope confirmed the indications already observed. The familiar milk-fat corpuscles were almost wholly absent, and in their stead was a mass of irregular fatty bodies, twenty-five to fifty times the size of milk-fat corpuscles, whose appearance suggested some vegetable oil admixture, possibly cotton-seed.

Consideration of the results shows that the addition of a little coloring matter would have placed the milk beyond the reach of ordinary inspection methods, while the determination of solids and the microscope proved conclusively a skillful adulteration. It will be noted that the lactometer failed to detect the abnormal solids, as it depends for its data upon Sp. G., while the lactoscope and extraction processes showed about five per cent. of fat, which the microscope proved to be almost wholly foreign to milk.

My own experiments, confirmed by many others, show that milk solids are among the least variable factors in milk analysis, as the average milk containing 3.5 per cent. of milk fat is nearly always found to contain about 12.5 per cent. of solids, while Jersey milk with 4.5 to 5.0 per cent. of fats never exceeds 14.5 per cent. of solids. It will be observed, that the milk referred to gave 19.7 per cent. of solids and nearly 5.0 per cent. of a substituted oil.

As long as milk inspection is confined to the use of instruments in the hands of unskilled inspectors, the dishonest creamery, backed up by professional chemical skill, will continue to furnish a cheap, fabricated article, which savors less and less of its reputed origin and character.

Indianapolis, Dec. 2, 1895.

Ratio of Alcohol to Yeast in Fermentation. By Katherine E. Golden.

Fermentation is, essentially, the breaking up of chemical compounds into simpler and more stable compounds. Some form of fermentation goes on in all living cells, the nature of the fermentation and the resulting products depending on the organism and the body fermented. The results may be simple, as, for example, where a single organism is used, or complex where a number of organisms are working together. Where a single organism is used, the predominating resulting product gives the fermentation its name.

In the alcoholic fermentation, besides the alcohol are formed CO_2, succinic acid, glycerine and a number of by-products, the nature and quantity of which depend on the orgenism, and the conditions under which it is grown. Beers and wines depend mainly on these by-products for their aroma and special character, so that experimenters, using the same kind of grape, have obtained many different wines; the same way for beers, using the same wort, but varying the yeast, different beers are obtained. Even from apple must good wines have been produced, by the use of certain yeast cultures. Again, mixing certain yeasts in the brewing, characteristics are obtained which are impossible with a single form. Large breweries now have competent bacteriologists, who seem to the uninitiated, to be able to manipulate their yeasts, molds and bacteria much as a juggler does his implements.

Yeast is the organism most commonly used to induce the alcoholic fermentation, though it can be induced also by certain bacteria and molds. The yeast which is used in brewing is S. cerevisiæ, there being two well marked varieties, the cerevisiæ, which produces top fermentation, and that which produces bottom fermentation. Top yeast works at a comparatively high temperature, the action is rapid, and the yeast rises to the surface of the liquid; this is used in the brewing of ale and porter. Bottom yeast works at a low temperature, the action is slow, and the yeast is at the bottom of the liquid; the bottom yeast is used in the brewing of lager beer.

Wort, which is the basis of beer, is made in the following manner: First there is the malting of the grain, which consists of the germination; then the stoppage of the germination by heat. The first stages are for the purpose of changing the chemical constitution of the grain; diastase is developed from the albuminoid matter; the diastase then acts on the starch, changing it to maltose and dextrine. When this development has reached the proper point, the germ is killed by drying. The grain is then cleaned and crushed and placed in warm water to allow the diastase to act still further on the starch, the completion of this

process being determined by the iodine test. The solution is then drawn off and boiled, hops being added. The hops give to the beer a bitter taste, besides aiding in its keeping; they also, by means of their tannic acid, facilitate the coagulaion of the protein material, which is going on by means of the boiling. The wort is then cooled rapidly, after which it is ready for fermentation.

There are different methods used by manufacturers in the fermenting of the wort, but by whatever method there are always three stages into which the fermentation can be divided: the *main fermentation*, which begins in a short time after the yeast is added, during which time the maltose is decomposed, new yeast cells are formed and a rise in temperature takes place; the *after fermentation* is the next stage; maltose continues to be decomposed, the formation of yeast cells nearly ceases, the yeast settles and the beer clears; the last stage is the *still fermentation*, maltose is still decomposed, dextrine is changed into maltose, but no new yeast cells are formed. The *main fermentation* lasts from four to eight days; the other stages vary in time, and are controlled by changing the conditions.

In the experiments which I made the study was on the main fermentation, and was to determine the ratio between the amount of alcohol and the number of yeast cells formed. Wort, that was ready for fermenting, was obtained from one of the breweries, filtered, then placed in flasks, and sterilized by the fractional sterilization method. Two litres were used in a flask. Pure yeast, which had been separated from a compressed cake by the Hansen orientation method, was used; a colony, which had been grown from a single cell, was placed in 5cc. of wort in a test tube, and allowed to remain there twenty-four hours. This quantity was then added to the wort in the flask. This corresponds to the method employed in breweries, where a quantity of yeast is first grown in a small amount of wort; this quantity, called "pitching yeast," then added to the main quantity that is wanted for beer. After the addition of the pitching yeast, the flask was shaken thoroughly, and 1 cc. taken out with a sterilized pipette, for the purpose of counting the yeast cells. To the 1 cc. was added 1 cc. dilute H_2SO_4 for preventing further growth of yeast, and also for dilution. The wort was kept in a constant temperature oven at 25°c., this being a temperature at which the yeast grows vigorously.

At the end of every twenty-four hours for seven days the flask containing the wort was shaken vigorously for some time, so as to distribute the yeast cells thoroughly, then 1 cc. taken in the manner described, and also 200 cc. for determining the alcohol. The alcohol was estimated by direct distillation; 100 cc. was distilled over, then an accurately tared pycnometer of 50 cc. capacity used for the weighing. When the temperature varied from 15.5°c., Allen's formula for

correcting the density was used. $D = D' + d\,(.00014 + \frac{1-D}{150})$ D = required density; D' = observed density; d = difference in temperature between 15.5°c. and observed temperature.

After the specific gravity of the distillate was obtained, Allen's tables were used for determining the per cent. of absolute alcohol.

The apparatus for counting the yeast cells was made by taking a thin strip of brass, cutting an oblong hole through it, then cementing a strip of glass to one side of it, and using a similar strip for a cover on the other side. This gave a chamber of known dimensions, so that when the yeast liquid was placed in it the thickness of the layer was known. To obtain the other two dimensions, a micrometer having small squares engraved on it was placed in the eye-piece of the microscope, and the value, with a system of lenses then determined. The cell contents of a number of these squares were counted, and the average obtained. To determine the number of squares to be counted, countings and determinations were made until the number obtained had no influence on the average. This number of squares was then used on duplicate samples:

ALCOHOL.

No.	*Hours.*	*Sp. gr. alc.*	*Per cent. abs. alc. by wt.*	*Per cent. inc. alc. per day.*
1.	24	.9915	2.41	
2.	48	.98498	4.60	2.19
3.	72	.984215	4.89	.29
4.	96	.98337	5.22	.33
5.	120	.98297	5.405	.185
6.	144	.98277	5.500	.095
7.	168	.9826	5.575	.075

YEAST.

No.	*Hours.*	*No. cells in .02 c. mm.*	*Increase per day.*
1.	½	1.9	
2.	24	36.5	34.6
3.	48	55.6	19.1
4.	72	74.8	19.2
5.	96	95.6	20.8
6.	120	107.1	11.5
7.	144	112.6	5.5
8.	168	118.2	5.6

The table shows clearly that as the yeast cells increased in number the quantity of alcohol also increased in a nearly corresponding degree, so that, taking the results at the end of twenty-four hours, there is a direct ratio between the two. During the first twelve hours this does not hold good, as during approximately that period there is a large growth of yeast, but no apparent fermentation, as is evidenced by the lack of gas given off. For this reason the time between the "pitching," or inoculation of the wort, and the beginning of active fermentation is called the "incubation" period.

Thanks are due to Mr. W. H. Test for assistance rendered in the work.

The Circulation of Protoplasm in the Manubrium of Chara—Chara Fragilis. By D. W. Dennis.

About the middle of May last Mr. Omer Davis, a student in the Biological Laboratory, at Earlham, while studying the fertilization of Chara Fragilis noticed that the nucleus of the manubrium traveled rapidly around the periphery of the cell, with the circulating protoplasm. The phenomenon was subsequently noticed by all the members of a class of eighteen, and the attention of many other persons was called to it, some of whom were familiar with many of the phenomena of moving protoplasm in the leaves of Chara, the stamen hairs of Tradescantia and in other stock illustrations, it astonished all alike. The circuits of the nucleus were timed by Mr. Davis and myself, and found to range from 15, when the phenomenon was first noticed, to 26, something like a half hour later in a minute.

The circuit of this particular cell was not measured, but a measurement of a large number of cells later convinces me that it could not have been less than five-eighteenths of a mm. This gives a rate of 7.2 millimeters in a minute, or more than four times as fast as the fastest rate given in Goodale's Physiological Botany for protoplasm in a closed cell. I reported these facts to Prof. Barnes, who said they were, so far as he could learn, entirely new, and he asked me to prepare the matter for publication in the "Botanical Gazette." Early ni June I began what I hoped to make an exhaustive study of the phenomenon for this purpose, but could not find a single case in which the motion was going forward. Disintegration had taken place in most of the cells, and in all the motion had stopped. The phenomenon seems, therefore, to be one connected with the growth and maturation of the cell in which it occurs. All I can say is that next May we shall permit nothing to interfere with the most exhaustive study we can give to the

phenomenon. The observation requires no skill except what is necessary to find the male organs of reproduction at the right time, and crush them under the coverglass and recognize the manubrium. If nothing else comes of it it can not fail to add one, and that one the most striking and one of the most easily attainable of all, to the stock illustrations of the circulation of protoplasm.

Fungicides for the Prevention of Corn Smut. By Wm. Stuart.

During the present century the disease of the corn popularly known as "corn smut" (*Ustilago zeæ-mays*, [*DC.*] *Wint.*) has engaged the attention of some of its most eminent botanists. It has only been within the last half of the present century that the life history of the fungus has been well understood. When we consider that corn is the principal cereal crop of America, it is not to be wondered at that any fungus disease causing it much apparent injury should arouse a desire on the part of investigators to devise some means of preventing it.

The successful treatment of the smuts of wheat and oats by disinfection of the seed, either by hot water or chemical solutions, naturally turned the attention of Experiment Station workers to employing the same remedies for the smut of corn. The experiments of Arthur,[1] of Indiana, Kellerman and Swingle,[2] of Kansas, and those of Pammel and Stewart,[3] of Iowa, are perhaps the most noteworthy. These experiments included the disinfection of the seed by hot water and chemical solutions; the attempted infection of the seed by rolling in the spores of the smut; and the spraying of the plants with fungicides, the latter experiment being conducted by the Kansas Experiment Station[4] in 1890. The results of all these experiments were of a negative character, due to the fact that the fungus plant of the corn smut, unlike that of wheat and oats, can enter any young growing tissue of the host, while in the last two mentioned it can only enter the host when it is very young. This point has been ably demonstrated by Brefeld,[5] who, by a long series of carefully conducted experiments, showed conclusively that the germinating spores, or conidia, are capable of penetrating any portion of the young

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[1]Fourth Annual Report Indiana Experiment Station.

[2]Kansas Experiment Station Bulletins, Nos. 22, 23, 40, 41.

[3]Iowa Experiment Station Bulletins Nos. 16, 20, Proceedings of Iowa Academy of Sciences, 1894, p. 74.

[4]Kansas Bulletin No. 23, p. 101.

[5]Journal of Mycology, Vol. VI, Nos. I, II, and IV. (Translated from Nachrichten aus dem Klub der Landwirthe zu Berlin, Nos. 220, 222, by Erwin Smith.)

growing tissue of the host. It would therefore follow that the growing corn plants are susceptible to infection during the greater part of their growth, or until the fertilization of the pistils.

Realizing the importance of ascertaining some method for the prevention of the smut, the botanical department of the Indiana Experiment Station undertook, during the past season (1895), to carry out an experiment having as its main object the spraying of the plants with the best known fungicides. A portion of one of the Station cornfields was set aside for the experiment. In order to avoid any possibility of infection through smutted seed, a portion of the seed was treated with a copper sulphate solution, another with an ammoniacal copper carbonate solution, and a third with hot water, while a fourth portion was infected with germinating smut spores. The experimental plat was divided into five sections, as follows:

Section I. Seed untreated.

Section II. Seed treated with copper sulphate solution one-half hour.

Section III. Seed treated with ammoniacal copper carbonate solution one hour.

Section IV. Seed treated with hot water at 60° C. for five minutes.

Section V. Seed dipped in a nutrient solution containing germinating smut spores.

The plat was planted May 18th, and on June 8th when the plants were about six inches high, two cross sections containing five rows each were sprayed by means of a knapsack sprayer, the one with Bordeaux mixture and the other with ammoniacal copper carbonate. This divided the plat into twenty-five lesser ones, as will be seen by the following diagram:

1	6	11	16	21	Sec. I.
2	7	12	17	22	Sec. II.
3	8	13	18	23	Sec. III.
4	9	14	19	24	Sec. IV.
5	10	15	20	25	Sec. V.

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The strength of the Bordeaux solution consisted of six pounds of copper sulphate, four pounds of lime and fifty gallons of water, while that of the ammoniacal copper carbonate consisted of one ounce of copper carbonate dissolved in ammonia and diluted with nine gallons of water. The latter solution proved too strong, some of the plants showing considerable injury two days afterwards. Subsequent sprayings were made with a much weaker solution.

The plats were sprayed quite frequently during June. In July, owing to the absence of the writer during the early part of the month, and frequent showers during the middle part of it, the sprayings were somewhat interrupted. The partial failure of the fungicides in completely preventing the smut may be largely attributed to these facts:

On July 20th some injury to the plants from the Bordeaux was noted, and for the remaining sprayings the strength of the solution was reduced one-third. The last spraying was made August 14th, the plants being then supposed to be too mature for infection.

The dates of spraying were as follows:

Bordeaux.	Ammoniacal Copper Carbonate.
June 8	June 8
	June 12
June 13	June 13
June 17	June 17
	June 19
June 21	June 21
June 27	June 27
July 5	July 5
July 20	July 20
July 25	July 25
August 3	August 3
August 14	August 14

Just previous to harvesting the crop a careful record of the number of smutted stalks was made and gave the following percentages of smutted stalks:

Unsprayed plants .... 13.37 per cent.

Those sprayed with Bordeaux .... 3.83 per cent.

Those sprayed with ammoniacal copper carbonate, 6.72 per cent.

It will be readily seen from the above figures that there is a marked difference in the amount of smut between the sprayed and unsprayed plats.

SUMMARY.

The results of this experiment show conclusively:

That the Bordeaux mixture, properly applied to the plants during their period of growth, does materially lessen the smut.

That the ammoniacal copper carbonate was not as effective as the Bordeaux in preventing the smut.

That frequent applications of the fungicides are necessary during the growing period of the plant in order to be effective.

A New Station for Pleodorina Californica Shaw. By Severance Burrage.

During an investigation of the sanitary condition of the Wabash and Erie Canal as it runs through Lafayette, made in the laboratories at Purdue in September of the present year, *Pleodorina* was found in considerable abundance in the canal water. This comparatively new member of the *Volvox* family was first described by Walter R. Shaw, of Leland Stanford University, who found the plant in a ditch in Palo Alto in September, 1893 (" Botanical Gazette," Vol. 19, p. 279). Since then D. M. Mottier has reported it in Bloomington, Indiana, in May, 1894, and Messrs. Clinton and Burrill in Havana, Illinois (" Botanical Gazette," Vol. 19, p. 383), in June of the same year. It is now possible to add another station in Indiana, namely, Lafayette.

The microscopical examinations were made according to the Sedgwick-Rafter method, which has been used for several years by the Massachusetts State Board of Health in the enumeration of microscopical organisms, exclusive of bacteria, in water supplies. The average number of *Pleodorina* in one cubic centimeter of the canal water was four. The census of other organisms found in the same samples included, on the vegetable side, *Hydrodiction*, *Chara*, and *Spirogyra*, too large and abundant to enumerate; *Diatoms*, per cubic centimeter, eight; *Oscillaria*, fifty-six; *Anabaena*, three; *Scenedesmus*, one; *Protococcus*, eight; *Crenothrix*, ten; *Pandorina*, one; *mold hyphae*, three; and, on the animal side, principally *infusoria*, as *Peridinium*, two hundred and ninety-six; *Monas*, four; *Trachelomonas*, three; *Dinobryon*, three; and a few *Rotifera* and *Acarina*. The water was quite turbid, and had the general appearance of dilute sewage, and in fact the water of the canal was evidently polluted. This shows the nature of the water in which *Pleodorina* seems to flourish in Lafayette, and also many of its companions.

But, aside from the interest attached to this new genus of the *Volvocinae* from the botanical point of view, it may be found to have important relations to odors and tastes in water supplies, when it will become the enemy of engineers and water commissioners, as other members of this group have done before. For example, *Volvox globator* has caused much trouble in Rochester, N. Y., by imparting a disagreeable fishy odor to the city water supply, and in Massachusetts *Pandorina* and *Eudorina* have caused similar troubles on a smaller scale. *Pleodorina*, coming as it does between *Volvox* and *Eudorina* in the classification, may be looked upon with suspicion in this respect, if it ever infects a water supply in a sufficient quantity. On account of the filthy condition of the canal water in which it was found in Lafayette, and the number of other forms growing with it, no idea could be formed as to the nature of the odor, if any, of *Pleodorina*.

FORMS OF XANTHIUM CANADENSE AND X. STRUMARIUM. BY J. C. ARTHUR.

In the absence of the author the outline of the paper was presented by Mr. Wm. Stuart and photographs of the two species were shown. The species in their most typical forms differ widely in the outline of the leaf and character and size of the burs. *X. Canadense* has a flowing sub-entire outline to the leaf, and large, strongly hispid fruit covered thickly with prickles, while *X. strumarium* has dentate leaves and smaller glabrous fruit with fewer prickles. All gradations exist between the two types, due possibly to hybridization.

NOTES ON WOOD SHRINKAGE. BY M. J. GOLDEN.

The increase or diminution in size of a piece of wood, due to its possession of a greater or less amount of moisture, is well known, as is also the fact that this change in size may be accompanied by the expenditure of a great deal of force. If an unseasoned piece of wood has two sides fastened rigidly so that it can not shrink across the grain, and then be exposed to a current of comparatively dry air, it will very soon break, the break being in the direction of the length of the cells of which the wood fibers are composed; or if a piece of dry wood be confined rigidly to prevent any *increase* in size and then be saturated with moisture, it will tend to swell and the force will be sufficient to crush the fibers where they are in contact with whatever confines them.

This change in size occurs across the grain of the wood, or across the cells of which it is composed, and only to a slight degree in the direction of their length.

Some pieces of unseasoned poplar had iron bars ten inches long placed between the projecting ends to prevent the ends coming any nearer together, and were then allowed to remain in the conditions of ordinary workshop atmosphere until they broke, which they did in the average time of four hours after adjustment.

A number of tests made in a testing machine showed that a force of about 370 pounds to the square inch was required to break them.

Trials made with other wood gave corresponding results; in a few hours each piece broke, the force required to break it depending on the kind of wood. In some cases the force was over 600 pounds to the square inch.

A microscopic examination of sections made from some of the pieces after they had been allowed to dry, showed, first, a loss of the contained moisture, and, as the drying continued, in some cases what seemed a shriveling of the tissues of the side walls.

An examination, previously made, of the cell walls of some wood that had been in a dry place during some years showed a disintegration of the tissue, the cell walls having a rough and fibrous appearance.

In order to record any microscopic change taking place in the cell walls, two sections, one a transverse and the other a longitudinal radial one, were made from a freshly cut branch of *Pinus sylvestris* and mounted dry under cover glasses. They were photographed at intervals and records made of changes occurring in them. The moisture first dried out, the cells in transverse section becoming slightly less in size. After a few days when the moisture had dried from between the walls, the greater change seemed to take place in the longitudinal section, the walls of which began to shrivel slightly. This change continued for some weeks in a constantly lessening degree, however.

Botanical Literature in the State Library. By John S. Wright.

As a member of the Academy Committee on the State Library, sometime ago I made a list of the works in that institution which are upon botany and related subjects. The number of such books is small, the authorities who have in charge the purchases are inclined to increase the collection in lines of literature, biography and history rather than science. While it may be true that those who most use the library have greatest use for works of that nature, yet the State Library should also be the repository of the standard and best works in the various departments of science, especially of the larger and more expensive sets which are often beyond the purse of the individual worker.

In talking over this matter with the present Librarian and her predecessor each expressed a desire to make the sections of botany and other sections of scientific works what they should be. They also said that they would be glad of any suggestions, from those competent, as to additional purchases. In accordance with this wish about two years ago I prepared a circular letter addressed to the professors of botany in the several colleges of the State. This letter contained a list of the main botanical works then in the Library, and a request that they would recommend such others as they thought it should contain, giving the name of the publisher, place and date of publication and cost of each work so recommended. Nearly every one to whom a letter was addressed responded, and from these letters a list of books was compiled and recommended to the State Librarian for purchase, each one of which was accompanied by the name of the person or persons requesting its purchase and the other data mentioned. Since that time, however, the Library has changed management, has been thoroughly overhauled and rearranged, so the purchases asked for have not been made. The present Librarian, however, is quite favorable to the improvement of the Library in this respect and I believe that it is only necessary to bring a little influence to bear upon other library officials in order to secure to the Library a creditable number of botanical works of reference. While it will be impossible to withdraw books from the Statehouse, the establishment of such a collection should, nevertheless, be of interest to botanists of the State.

List of Works in State Library on Botany and Related Subjects.

An accurate classification could not well be made; many pamphlets on diverse subjects are bound together in one volume, and other works are general in character, not falling wholly under any single division.

Agriculture—

1. How Crops Feed, S. W. Johnson, 1882.
2. How Crops Grow, S. W. Johnson, 1888.
3. Resena sobre el cultive de algunas plantas industriales que se explo tan sou suscepttibles oc explotarse, J. C. Sequra, 1844.
4. Sugar Cane, the Nature and Property of, Geo. R. Porter, 1843.

Botany, General Works on—

British Wild Flowers in Relation to Insects, Sir John Lubbock, 1882.
Chronological History of Plants, Chas. Pickering, 1878.
Desmids of the United States, Francis Wolle, 1884.
Dictionary of Economic Plants, John Smith, 1882.
Encyclopedia of Plants, J. C. Loudon, 1841.
Ferns of North America, D. C. Eaton.
Ferns of North America, Native and Foreign, D. J. Browne, 1846.
Flora America Septentrionalis, Frederick Pursh, 2 vols., 1861.
Floral Stuctures, Origin of, Geo. Henslow, 1888.
Flowers and Ferns of the United States, Native and Foreign, Thos. Meehan, 188-.
Flowers, Fruits and Leaves, Sir John Lubbock, 1886.
Flowers, How to Know the Wild Flowers, Mrs. Wm. Starr Dana, 1893.
Fungi, Their Nature and Uses, M. C. Cooke, 1830.
Genera of the Plants of the United States, Gray & Sprague, 1849.
Genera Plantarum, 3 vols. of 7 parts, Benthan & Hooker, 1862.
Geological History of Plants, Sir Wm. Dawson, 1888.
Manual of Botany of North America, Amos Eaton, 1836.
Manual of Botany of Northern United States, Asa Gray, 1848.
Manual of Flora of the Rocky Mountains, J. M. Coulter, 1885.
Manual of Flora of Southern United States, Chapman, 1889.
Origin of Cultivated Plants, Alphonse DeCandolle, 1885.
Pamphlets on Botany (bound in one volume)—
Fern List of United States, Eaton.
Plants of United States, Horace Mann.
Forests and Forestry of Sweden, C. C. Andrews.
Duty of Preserving Forests, F. A. Hough.
Medicinal Plants of United States, A. C. Clapp.
El Algedoners, Donato, Gutierrez.
Development of Cork Wings, Emily Gregory.
Woody Plants of Ohio, J. A. Warder.

Plants of Michigan, Wheeler & Smith.

Physiology of Plants, J. Von Sachs, 1887.

Plants of Boston and Vicinity (Florula Bostoniensis), Jacob Bigelow, 1824.

Plants of North America, The, Frederick Pursh, 1816.

Plants of the United States, Geo. Putnam, 1849.

Sylva, The North American, 3 vols. 2 parts, Michaux, 1865.

Systematic and Physiological Botany, Introduction to, Nuttall, 1830.

Vegetable Mold, The Formation of, Darwin, 1882.

Forestry—

American Grove, Humphrey Marshall, 1785.

Forests and Moisture, J. C. Brown, 1877.

Forests of Northern Russia, J. C. Brown, 1884.

Forestry in Norway, J. C. Brown, 1884.

French Forest Ordinance of 1669, J. C. Brown, 187-.

Hydrology of South Africa, J. C. Brown.

Pine Plantations on Sand Wastes of France, J. C. Brown.

Practical Forestry, A. S. Fuller, 1884.

Schools of Forestry in Germany, J. C. Brown.

Trees of America, J. Brown, 1846.

Trees and Shrubs of Massachusetts, By Order of State Legislature, 1846.

Government Reports—

Agricultural Grasses and Forage Plants of the U. S., Geo. Vasey, 1889.

Contributions from U. S. National Herb. Botany of Western Texas, Coulter, 1891-4.

Journal of Mycology, Vols. 1-6, Bound.

Forestry—

Reports on Four Years, 1877, '78, '79, '82, '84, and '88.

Horticulture—

Elementary Treatise on American Grape Culture, W. R. Prince, 1830.

An Elementary Treatise on Grape Culture and Wine Making, P. B. Meade, 1867.

Cultivateur de Dahlias, Legrand, 1848.

Du Fuchsia, son Histoire et sa Culture, etc., ——— 1844.

Gardening, Encyclopedia of, J. C. Loudon, 1834.

Grape Culture, Wines and Wine Making, A. Haraszthy, 1862.

Hortus Botanicus Americanus, Sketches toward, W. J. Titford, 1812.

Horticulture Practique, G. Laroque, 1883.

Journal of Visit to Vineyards of Spain and France, Jas. Bushby, 1835.

Observations on Character and Cultivation of European Wine, S. I. Fisher, 1834.

Rural Essays on Horticulture, A. J. Downing, 1858.

The American Grape Growers' Guide, Wm. Charlton.

The Fruits and Fruit Trees of North America, A. J. Downing, 1886.

Theory of Horticulture, John Lindley, 1841.

Plants, Henderson's Hand Book of, Peter Henderson, 1881.

Plants and Fruits, Hand Book of, L. D. Chapin, 1843.

Trans. of Mississippi Valley Horticultural Society, 1883.

Vineyard Culture, A. Du Breinl, 1867.

Western Fruit Book, F. R. Ellicott, 1859.

Medical Botany—

Flora Medica, John Lindley, 1838.

Medical Botany, R. E. Griffiths, 1847.

Periodicals—

Botanical Gazette, partially bound, Vols. viii, x, xix, bound, x, xvi, xvii, xviii, incomplete and unbound.

Botanical Magazine, Curtis, Vols. 1-10 inclusive, 1793———.

MICROSCOPE SLIDES OF VEGETABLE MATERIAL FOR USE IN DETERMINATIVE WORK. BY JOHN S. WRIGHT.

In the determination of plants it is frequently necessary, or at least desirable, to make examinations of various organs with the aid of a lens. Seed markings, glandular structures and many portions of the flower upon which determinations are partly based may be so minute as to necessitate slight magnification for satisfactory work. For example we have in the *Euphorbias* and *Lobelias* many species in which the seeds are to the naked eye mere granules, but under a hand lens their surfaces are seen to be decidedly marked with irregular ridges and pits, or are handsomely sculptured. Many leaves contain glandular structures, or are covered with hairs or scales which can be best seen under the lens. In determining specimens on which such structures exist and are of value in classification, it is often desirable to compare them with like material from well determined herbarium specimens. Commonly the material for these comparisons is dug out of or cut off the herbarium specimen as it is needed from time to time and placed

loosely under the lens for examination, and after it has served the purpose of the moment is brushed aside and lost, or at best preserved in packets upon the sheet with the specimen from which it was taken. This method is mussy and eventually impairs the mounted specimens of an herbarium, and where there are many workers it is not economical of time. To avoid this is quite practicable through the preservation of all such materials dry in cells upon glass slips as opaque mounts for the microscope. The cells are built by gluing to the glass slips brass ring-, and the specimens are enclosed by cementing to the top of this ring the ordinary circular cover glass. The method of building this form of cell was suggested by Dr. Griffiths some years ago and is quite familiar. A cell of this form will not accommodate leaves and some other plant structures as well as another form of cell, which is made by gluing a rectangular frame cut from cardboard to the glass slip. A cell of this construction will contain small leaves entire or the tip and basal portions of larger leaves, which can be viewed from either side. A cell of this type must be enclosed by a rectangular cover glass. A supply of slips, upon which cells of various sizes have been built, may easily be kept on hand, and whenever it becomes necessary to remove from an herbarium specimen material for examination, it may be placed in a cell in manner best adapted for its display, labeled, and you have at once, at very small expense, a slide of vegetable material which will be ready for use at any future time; and, if such a collection of slides is properly classified and arranged, it forms a working adjunct to the herbarium of much value, and, besides, provides one constantly with available material for numbers of demonstrations in botanical work.

Hæmaglobin and Its Derivatives. By A. J. Bigney.

On subjecting a dilute solution of arterial blood to spectroscopic examination, certain parts of the spectrum of natural or artificial light will be absorbed. The amount of this depends upon the degree of concentration of the blood; if a one per cent. or two per cent. solution be used, two narrow dark bands are seen in the orange-yellow between the Frauenhofer lines D and E, the one next to E being a wider, but not so deep a band as the one next to D. A little of the red is absorbed and the violet, indigo, and a part of the blue. This is the spectrum of *Oxy.-Hæmoglobin.*

If arterial blood or venous blood which has been shaken with air be treated with some reducing agent such as ammonium sulphide or alkaline iron sulphate with tartaric acid, a decided change occurs in the spectrum, instead of the two

bands only one appears, which is between the two lines of *Oxy.-Hæmoglobin*, and is much broader than either of the bands mentioned above. This is the spectrum of reduced *Oxy.-Hæmoglobin* or simply *Hæmoglobin*.

METHÆMOGLOBIN.

The spectrum of *Methæmoglobin* is obtained by first preparing *Oxy.-Hæmoglobin* crystals by treating dog's blood with ether and shaking it until it becomes laky, then allowing it to stand in a cool place for an hour or so, at which time a firm mass will be formed, due to the crystals. The mother liquor is separated from the crystals by filtering through muslin or linen, squeezing the mass so as to obtain the crystals in as pure a form as possible. The crystals are dissolved in distilled water and a dilute solution is examined with the spectroscope. The two bands of *Oxy.-Hæmoglobin* appear. A few drops of potassium permanganate are added and the solution gently warmed. If sufficient time has elapsed for the oxidation of the *Oxy.-Hæmoglobin*, the two bands will have disappeared and instead a single band in the red near the line C between C and D. Nearly the entire spectrum is absorbed. Sometimes it is a little difficult to get this band, but if the oxidation has taken place it will be seen. In the experiment at hand I left the solution until the next day before it would give the above result.

CARBON-MONOXIDE HÆMOGLOBIN.

If coal gas be passed through blood which has been defibrinated, it will assume a cherry-red color, the carbon-monoxide of the gas having driven off the oxygen of the *Oxy.-Hæmoglobin* and taken its place. The reducing agents have no influence upon this new substance, it being more stable than *Oxy.-Hæmoglobin*. The two absorption bands are nearer to E than in the *Oxy.-Hæmoglobin* spectrum.

HÆMATIN.

The red corpuscles are composed of a *proteid stroma* and a brownish pigment which is called hæmatin. The iron is a part of the hæmatin. It can be obtained either as the acid hæmatin or the alkaline hæmatin.

In making the acid hæmatin, I took 100 cc. of 95 per cent. alcohol and added 2 cc. of sulphuric acid, and then 10 cc. of blood; the mixture was boiled for about an hour in a flask tube three or four feet long so that the vapor passing off would be condensed in upper part of the tube and flow back into the flask.

During this process a precipitate is formed which is acid hæmatin. The solution is filtered and the precipitate is dissolved in alcohol and then examined

Since the precipitate is soluble in alcohol, that which is obtained by filtering does not represent all the hæmatin, for a part would be dissolved while boiling. The spectrum has one broad band near C. Most of the remaining portion of the spectrum is also absorbed.

If 95 per cent. alcohol be added to blood and a small quantity of caustic soda, a still different spectrum is obtained. This is the alkaline hæmatin spectrum. It is similar to the acid hæmatin except the dark band is near and often on D.

Effect of Heat Upon the Irritability of Muscle. By A. J. Bigney.

In these experiments the gastrocnemious muscle of the frog was used. It was suspended in a moist chamber and the tendon attached to a lever for recording movements in contraction on a revolving drum. Surrounding the cylindrical moist chamber was another similar cylinder filled with water; near the bottom was a small tube about one-half inch in diameter passing from it at right angles and forming two sides of a rectangle, returned to the cylinder filled with water. By this arrangement the water could make a circuit through this tube and the cylinder. Heat was applied to the tube, and a thermometer was placed in the moist chamber.

The muscle was stimulated at different temperatures and the result recorded on the drum. Only making shocks were used in stimulation, this being regulated by the automatic maker, or breaker. Between 36° and 38° C, the contractions were the greatest, showing an increase in irritability. Between 39° and 40° the contractions ceased, heat rigor having set in. At the time the contractions ceased, the temperature was lowered and the muscle became irritable again. It would continue irritable for some time, but would soon become exhausted. After several hours' rest it would become quite irritable again.

Heat rigor began to set in at a little more than 36°, sometimes not until nearly 39°. It is different in different frogs and in different seasons. From 45° to 55° C. the rigor would usually be complete. The most important point to be secured is that temperature at which contractions cease and still when the temperature is lowered the muscle will be found to be alive so as to give contractions. When the heat rigor would once begin, it would continue even if the temperature is lowered. This holds true only for a few degrees. Long rest would allow it to pass out of rigor if it had not gone too far. After at least 24 hours had elapsed good contractions were obtained, and this with muscle that had once been exhausted.

A Revision and Synonymy of the Parvus Group of Unionidæ. (With Six Plates.) By R. Ellsworth Call.

The type of this group is a small unionine bivalve from the Fox river, Wisconsin, collected by Mr. H. R. Schoolcraft, while engaged in work on the Northwest Expedition, of the early part of the present century. The type was described by Mr. D. H. Barnes, in 1823, in the following words:*

"Shell oblong-ovate, small, convex, sides rounded; beaks slightly elevated, inside pearly white, iridescent. * * * *

"Diameter, .35—.525; length, .4 - .6; breath, .75—1.2.

"Shell rather thin, beaks placed about one-fourth of the length from the posterior extremity, ligament very narrow, anterior lunule distinct and obsoletely ribbed; basal margin slightly shortened; epidermis brownish; an obtuse, slightly elevated rib from the beaks to the anterior basal margin; lateral tooth rectilinear rounded at the end, and parallel to the base; nacre very brilliant."

Mr. Barnes completes his diagnosis of this form with the remark that it is "the smallest and most beautiful of all the genus yet discovered in America."

In geographic distribution this small mollusk ranges from Western New York and Florida, to Minnesota, Texas and Arkansas. In this wide range there are numerous diverse environmental conditions, and the species appears, in a definite sense, to have responded to these, and thus have been produced a number of variations, which passing through the hands of different naturalists, have been elevated into specific rank. In some cases, indicated below, the sexes have been made to serve as the basis of new species; full series collected over the wide area of distribution confirm the following synonymy, in which the geographic distribution of several of the forms conveys its own argument:

†Unio parvus Barnes.

Am. Jour. of Sci and Arts, 1st series. Vol. vi, 1823, p. 274, Fig. 18; Lea figures the animal in Jour. Phila. Acad. Nat. Sci., 2d series, Vol. iv, Pl. xxix, Figs. 102, 102a; Conrad, Monography of Unio, 1836, Pl. ix, Fig. 1; Reeve, Conchologia Iconica, Vol. xvi, *Unio* Pl. xxxv, Fig. 186, a very poor figure from a specimen in the Museum Cuming. (Pl. i, Figs. 1-3.)

Unio paulus Lea. Trans. Am. Philos. Soc., Vol. viii, 1840, p. 213, Pl. xv, Fig. 29. From the Chattahoochee river, Georgia. (Pl. ii, Figs. 11-13.)

Unio minor Lea. Trans. Am. Philos. Soc., Vol. ix, 1843, p. 276, Pl. xxxix, Fig. 3. From Lakes Monroe and George, Florida.

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* American Jour. of Sci., 1st Ser., Vol. VI, No. 2, p. 274, pl. 13, fig. 18, *outline only.*

† The plate references in parentheses are to the several plates accompanying this article. The sexes are indicated on the plates.

Unio marginis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. vi, p. 255, 1868, Pl. xxxi, Fig. 69. From Dougherty county, Georgia. (Pl. ii, Figs. 7-9.)

Unio corvinus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. vi, 1868, p. 310, Pl. xlviii, Fig. 123. From Flint river, Georgia, and Neuse river, North Carolina. (Pl. i, Figs. 4-6.)

Unio vesicularis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. viii, 1874, p. 37, Pl. xii, Fig. 34. From Lake Ocheechobee, Florida. (Pl. v, Figs. 35-37.)

So few of the animals of the *Unionidæ* have been described that it may not be superfluous to give at this place a description of the animal of *Unio parvus* (plate ii, fig. 10), based upon the examination of a fresh specimen from the Des Moines river in Central Iowa.

ANIMAL OF *Unio parvus*. Color of the mass, whitish; tentacular portion of mantle, dark brown, ending in a caruncle; labial palps, large, white, triangular, united at base and partially so over the posterior margin; external ctenidium, smaller than the internal, thicker and larger at the posterior extremity, which is rounded, and on the margin, which is marked by a double row of minute, white papillæ; ctenidia united above throughout their entire length, free below; internal ctenidium, white, ovate.

The mass of the animal within the cavity of the beak is light brown owing to the color of the large liver which shows through the thin tissues separating it from the chamber of the ctenidia.

The chief anatomical peculiarity *is the presence of the caruncle in the female.* This is somewhat separated from the main tentacular mass and is supported by a slender pedicel. Its function is unknown.

To complete the history of this species the following redescription of the shell of *Unio parvus* is presented, based upon specimens collected in the Wabash River, Indiana:

Shell, small, compressed, rather thin, elliptical, rounded anteriorly and slightly thicker, posteriorly triangulate in the male and occasionally sulcate in the female, thinner; *umbonal* slope somewhat depressed; *umbones* rather prominent, with four to five coarse undulations; *epidermis*, thin, olive-green over most of disk, but much lighter on the umbones, striate, especially over the middle disk thence to the margin; in the young two broadening green bands often extend from the umbones over the posterior slope to the posterior margin, otherwise eradiate; *ligament* small, light brown in color, thin, rather long, but very narrow; *hinge teeth* small, all double in the left and single in the right valve, the *cardinals* erect, thin, lamellar, acuminate, crenulate, separating, the *laterals* long, lamellar, straight,

smooth, forming a very obtuse angle with the cardinals; *anterior adductor cicatrices* distinct, deep, that of the *protractor pedis* very small; *posterior adductor cicatrix* scarcely evident, confluent; *pallial line* distinct for the anterior two-thirds; *dorsal cicatrices* irregularly grouped in the rather large cavity of the beaks, minute; nacre white, iridescent posteriorly.

	Length.	*Height.*	*Width.*	
No. 1.	42.00 mm.	26.00 mm.	23.00 mm.	Female.
No. 2.	36.30 mm.	27.57 mm.	19.25 mm.	Female.
No. 3.	*36.10 mm.	18.00 mm.	14.60 mm.	Male.

UNIO TEXASENSIS Lea.

Proc. Acad. Nat. Sci. Phila, Vol. ix, p. 84, 1857; Jour. Acad. Nat. Sci. Phila., Vol. iv, pp. 357, 359, 362, Pl. lxi, Fig. 184, 1860; Observations on the *Genus Unio*, Vol. viii, p. 39, Pl. lxi, Fig. 184 (Pl. v, Figs. 38-40). Dewitt Co., Texas.

Unio bairdianus Lea. Proc. Acad. Nat. Sci. Phila., Vol. ix, p. 102, 1857; Jour. Acad. Nat. Sci., Vol. iv, pp. 360, 361, Pl. lxi, Fig. 186, 1860; Observations on the *Genus Unio*, Vol. viii, p. 42, Pl. lxi, Fig. 186 (Pl. vi, Figs. 41-43). Devil's River, Texas.

Unio bealii Lea. Jour. Acad. Nat. Sci. Phila., Vol. v, p. 204, Pl. xxx, Fig. 273, 1866; Observations on the *Genus Unio*, Vol. ix, p. 26, Pl. xxx, Fig. 273 (Pl. vi, Figs. 44-46). Leon County and Rutersville, Texas.

The conchologic characters of this form do not widely vary. As may be seen the species only comes from Texas, and contiguous portions of Louisiana.

The following description may assist in understanding the relation which this form sustains to the common and widely distributed type of the group.

Shell small, very elliptical, especially in the female, compressed laterally, rounded before, biangulate posteriorly though this character is less marked in the female, which is somewhat regularly rounded, striate; valves rather thin though somewhat thickened anteriorly; epidermis rather thick, olive-green, in young specimens with occasional rather broad greenish lines along the angles of the posterior umbonal slope; lines of growth numerous, fine and closely arranged, in old specimens often forming raised ridges along the ventral posterior margins; ligament long, smooth, light horn colored and shining, very narrow; umbones scarcely prominent, close together, rather coarsely undulate, the undulations being concentrically arranged as seen in young specimens; in the young the

*This is a large male specimen from the Wabash River, Indiana. In it the cardinal teeth are *double in both valves*; the posterior cardinal in the left valve is curved *dorsad* and is very long and thin, its edges are sharply serrate.

epidermis over the umbones is very light or straw-yellow in color; the dorsal aspect of the posterior umbonal slope is characterized by the presence of two rather indistinct and obtuse angles which extend from the umbones and, reaching the posterior margin, form the characteristic biangulation seen in the male; *cardinal* teeth short, acuminate, single in the right and double in the left valve, the single tooth being flattened and plate-like, the double tooth somewhat more trigonal and heavier, all crenulated on the margins; the posterior teeth are long, slightly curved, and lamellar; plate between the cardinal and posterior teeth scarcely evident; the anterior adductor cicatrices are large, and deeply impressed, entirely distinct from that of the *protractor pedis* impression which is deep and often pit-like; the posterior cicatrices are confluent, scarcely evident, that of the *retractor pedis* muscle being placed at extreme end of the posterior hinge teeth; dorsal cicatrices arranged, usually, in a line of five or more in the shallow cavity of the umbones, though in an occasional specimen they are grouped; the pallial cicatrix is faintly but regularly impressed throughout its entire length; nacre white, with tendency to salmon in the cavity of the umbones, beautifully iridescent posteriorly.

The four specimens on which this diagnosis is based are from Lake Caddo, Louisiana. Their dimensions are the following, the first being that of a female; comparison with the remaining three will evidence the more compressed character of the male shell:

	No. 1.	No. 2.	No. 3.	No. 4.
*Length	40.00 mm.	36.50 mm.	39.50 mm.	38.50 mm.
Height	24.00 mm.	20.00 mm.	22 00 mm.	21.50 mm.
Breadth	18.51 mm.	14.50 mm.	14.50 mm.	13.00 mm.

The habits of this form are quite similar to those of the type of the group. It delights in still water with muddy bottoms, and usually occurs in very great numbers wherever it is found at all.

As may be seen by comparing the figures given in the plates, which are copies of Lea's original figures, this form illustrates the erection of a species name upon characters that are but an expression of sex.

*The anatomy of the animal has been considered, rather than authority, in the terminology adopted. Thus the *length* is the extreme distance from the anterior to posterior margin; the height the distance from ligament to the ventral margin; the width the distance measured by a line drawn through the animal, transversely, from valve to valve. This appears both natural and satisfactory. Say, Kirtland, Barnes, Sowerby and others with them confused the anterior and posterior ends; Lea did not make this blunder, but made others equally reasonless. Thus the distance from valve to valve he calls the *heighth*, as if the normal or proper position of the animal was on one of its valves. Some later writers apparently have such reverence for these blunders that they still employ an obsolete terminology.

UNIO GLANS Lea.

Trans. Am. Philos. Soc., Vol. iv, p. 82, Pl. viii, Fig. 12, 1830; Observations on the *Genus Unio*, Vol. i, p. 92, Pl. viii, Fig. 12. Ohio River (Pl. iii, Figs. 14–16).

Unio pullus Conrad. Monography Family *Unionidæ*, pp. 100, 101, Pl. lv, Fig. 2, 1836. Wateree River, South Carolina (Pl. v, Figs. 32–34).

Unio granulatus Lea. Proc. Acad. Nat. Sci. Phila., Vol. xiii, p. 60, 1861; Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 48, Pl. xvi, Fig. 46, 1866; Observations on the *Genus Unio*, Vol. xi, p. 52, Pl. xvi, Fig 46. Big Prairie Creek, Alabama (Pl. iv, Figs. 23–25).

Unio germanus Lea. Proc. Acad. Nat. Sci. Phila., Vol. xiii, p. 40, 1861; Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 49, Pl. xix, Fig. 54, 1866; Observations on the *Genus Unio*, Vol. xi, p. 53, Pl. xix, Fig. 54. Coosa River, Alabama (Pl. iv, Figs. 26–28).

Unio cromwellii Lea. Proc. Acad. Nat. Sci. Phila., Vol. xvii, p. 89, 1865; Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 258, Pl. xxxi, Fig. 73, 1868; Observations on the *Genus Unio*, Vol. xii, p. 18, Pl. xxxi, Fig. 73. Kiokee Creek, Albany, Georgia (Pl. iv, Figs. 29–31).

Unio cylindrellus Lea. Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 308, Pl. xlviii, Fig. 121, 1868; Observations on the *Genus Unio*, Vol. xii, p. 68, Pl. xlviii, Fig. 121. East Tennessee, North Georgia, North Alabama (Pl. iii, Figs. 17–19).

Unio corvunculus Lea. Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 314, Pl. l, Fig. 127, 1868; Observations on the *Genus Unio*, Vol. xii, p. 74, Pl. l, Fig. 127. Swamp Creek, Whitfield County, Georgia (Pl. iii, Figs. 20–22).

The following conchologic description is based upon material taken in the White River, Indiana, where the species attains its maximum development, both in point of size and abundance.

Shell small, elliptical, striate, rather thick and subangulate posteriorly, much thicker anteriorly and rounded; *umbones* elevated, coarsely undulate, with irregularly crescent-shaped folds, three or four in number; epidermis rather thick, dark greenish, obscurely radiate over the anterior portion of the disk, a character best seen by transmitted light, somewhat polished over the umbonal slope and generally glossy, lighter colored on the umbones; posterior margin sulcate in the female, dorsal portion produced; *ligament* small, horn-colored, thin; both cardinal and posterior *hinge teeth* double in the left and single in the right valve, the *cardinals* short, thick, heavy, serrate; *laterals* rather long, striate, straight, lamellar;

anterior adductor cicatrices distinct, pit-like and deep; *posterior adductor cicatrices* shallow, confluent, that of the *retractor pedis* muscle impressed at tip of the laterals and below; *pallial cicatrix* evident, regularly impressed and linear; *dorsal cicatrices* several, crowded, in the deep cavity of the umbones or on the margin of the plate joining the hinge teeth; *cavity* of the umbones rather deep; nacre purple, with anterior margin usually white, whole posterior region beautifully iridescent.

NUMBER.	LENGTH.	HEIGHT.	BREADTH.	SEX.
1....................	34.40 mm.	22.10 mm.	19.51 mm.	Female.
2....................	28.00 mm.	20.00 mm.	16.12 mm.	Female.
3	28.50 mm.	20.20 mm.	17.00 mm.	Female.
4....................	37.10 mm.	22.32 mm.	17.24 mm.	Male.
5....................	37.56 mm.	23.44 mm.	18.50 mm.	Male.
6....................	33.00 mm.	21.50 mm.	16.88 mm.	Male.
7....................	30.28 mm.	20.10 mm.	16.50 mm.	Female.
8....................	34.60 mm.	22.92 mm.	17.10 mm.	Male.

Some interesting features connected with the comparative dimensions of the sexes may be shown from this table of measurements. If the two longest males be selected the ratio of length to height is $\frac{37.56}{23.44} = 1.60 +$ and $\frac{37.10}{22.32} = 1.66$. In these same shells the ratio of length to width is as follows: $\frac{37.56}{18.50} = 2.00$ and $\frac{37.10}{17.24} = 2.15$.

A comparison of the same dimensions for the two longest females develops the following ratios: $\frac{34.40}{22.10} = 1.55$ and $\frac{30.28}{20.10} = 1.50$. Comparing the lengths with the widths the ratio established is $\frac{34.40}{19.51} = 1.76$ and $\frac{30.28}{16.50} = 1.83$. The ratios show that the females are much wider than the males, a relation probably due to the requirements of the *ctenidia* of the female shells when functioning as gestatory sacs. So marked, even to casual observation, are these relations that it is an easy matter to select the sexes in any considerable number of shells.

The habits of *Unio glans* are somewhat different from those of *Unio parvus*. It more commonly affects gravelly beds, in shallow running water. The writer has taken the *corvunculus* form in great abundance in the typical locality, whence it was traced into nearly all the streams of north Georgia and Alabama, in the Gulf drainage. The *cylindrellus* form is very abundant in the smaller streams of

south Tennessee and in the Black Warrior River of Alabama. The heaviest, largest and *glans* like forms from the south occur in the Coosa River, a tributary to the Alabama, just above Wetumpka. Similar shells were taken in numbers in the Cahaba River, in Bibb County, also tributary to the Alabama.

UNIO AMGDALUM Lea.

Observations on the Genus Unio, Vol. IV, p. 33, pl. XXXIX, fig. 1, 1843, from Lake George, Florida; Trans. Am. Phil. Soc., 2d Ser., Vol. IX, pl. 39, fig. 1, pp. 275, 276. See also Simpson, "Notes on Florida Unionidæ," Proc. U. S. Nat. Mus. Vol. XV, pl. LXVII, fig. 3, p. 426, 1892.

Unio papyraceus Gould. Proc. Bost. Soc. Nat. Hist., Vol. II, p. 53, 1845. Florida. Latin diagnosis; no figure.

The following description of *Unio amgdalum* is based upon excellent specimens from the original locality.

Shell small, striate, somewhat inflated, nearly oval in outline, rounded before, subangular posteriorly, viewed dorsally the outline is rounded cuneate posterior to the umbones, female slightly emarginate on the ventral border; epidermis striate, light straw colored over the disk, greenish to greenish-yellow near the ventral margin, faintly rayed on the posterior dorsal slope in the manner characteristic of all the *parvus* group; ligament short, thin, light horn-colored; lines of growth distinct, broad, and much darker than the balance of the disk; anterior or cardinal teeth double in the left and single in the right valve, though an occasional specimen exhibits a tendency to double teeth in both valves, flattened, plate-like, crenate; posterior teeth double in the left and single in the right valve, long, lamellar, straight, striate, particularly toward the extremities; anterior cicatrices distinct, the adductor rather deeper or impressed, that of the *protractor pedis* rather large, oval, but slightly impressed; posterior cicatrices confluent, scarcely impressed, very iridescent; cavity of the beaks rounded and shallow, with a row of pit-like and minute cicatrices just under the dorsal plate; nacre white, pinkish or salmon tinged towards the cavity of the beaks, beautifully iridescent over the entire posterior half, but the play of iris-like colors is most marked on the posterior margin beyond the pallial cicatrix, which is very faintly impressed.

The average dimensions are: Length, 3.1 mm.; width, 1.22 mm.; heighth, 1.82 mm.

Some specimens of this shell approach the form of *Unio minor* Lea in that the cardinals are much heavier than usual and the substance of the shell is much thicker; in these forms also the posterior teeth are incrassate. The *tout ensemble*

of this shell is in no respect dissimilar from forms of *Unio parvus* found in gravelly river bottoms in more northern regions, and it is very doubtful if it can maintain a place in the system as a separate or distinct species. The species belongs to the *parvus* group without a question, though the specimens under examination are eroded and do not exhibit the characteristic coarse undulations on the umbones. In all other particulars my shells are typical.

To complete the history of these small and difficult forms the original diagnoses of Lea, except one, and Conrad have been tabulated and thrown into synoptical form as follows:

SYNOPSIS OF THE SPECIFIC CHARACTERS OF THE PARVUS GROUP.

UNIO.	PARVUS.	CORVINUS.	MARGINIS.	PAULUS.	GLANS.	CYLINDRELLUS.	CROMWELLII.	GRANULATUS.
Outline	Elliptical, somewhat compressed.	Elliptical, inflated.	Elliptical, inflated.	Elliptical, inflated.	Ovate-elliptical, inflated.	Widely elliptical, somewhat cylindrical.	Elliptical, somewhat inflated.	Elliptical, somewhat inflated.
Substance of shell	Thin, slightly thicker before.	Somewhat thick, thicker before.	Somewhat thick, thicker before.	Thick, thinner behind.	Rather thick.	Thick, thicker before.	Rather thin, thicker before.	Rather thin, slightly thicker before.
Beaks	Slightly prominent, coarsely and concentrically wrinkled.	A little prominent.	Somewhat prominent.	Somewhat prominent.	Somewhat prominent.	Slightly prominent.	Somewhat prominent; concentrically folded.	A little prominent, undulate, granulate.
Ligament	Small, thin, light straw-colored.	Short, thin, very dark brown.	Small, thin, light brown.	Short, thin.	Small.	Rather long, thin.	Small, thin, rather light brown.	Small, thin, light brown.
Epidermis	Yellowish green, lighter on beaks, striated, lines of growth distant, black.	Black, eradiate, subsquamose, growth lines close.	Dark olive striate, obscurely rayed, margin greenish-yellow.	Nearly black.	Black or dark brown, sometimes rayed.	Yellowish, eradiate, lines of growth distant.	Striate, brownish or greenish rayed, growth lines distant, broad.	Dark olive, eradiate, striate, lines of growth distant.
Cardinal teeth	Small, elevated, acuminate, crenulate, double in the left, single in the right valve.	Small, decussate.	Small, sulcate, crenulate.	Small, disposed to be double in both valves.	Rather large, elevated, double in left, single in right valve.	Small, sub-conical, corrugate.	Small, compressed, corrugate, double in both valves.	Small, compressed, crenulate, oblique, double in both valves.
Lateral teeth	Slightly curved, long, lamellar.	Long, somewhat straight.	Rather short, straight.	Long, curved.	Straight, lamelliform.	Long, somewhat curved.	Rather long, somewhat curved.	Long, acicular nearly straight.
Anterior cicatrices	Distinct, moderately impressed.	Distinct, small, well-impressed.	Confluent, small, deeply impres'd.	Distinct.	Distinct.	Distinct, small, well impressed.	Scarcely distinct, large, well imp.	Distinct, rather large, well imp.
Posterior cicatrices	Confluent, slightly impressed.	Confluent, slightly impressed.	Confluent, small, slightly imp.	Confluent.	Confluent.	Distinct, small, slightly imp.	Confluent, rather large, slightly im.	Confluent, rather large, slightly im.
Dorsal cicatrices	Center of cavity of the beaks.	Center of cavity of the beaks.	Center of cavity of shell [beaks].	On inferior part of tooth.	Center of cavity of the beaks.	Center of the cavity of the shell.	Center of cavity of the beaks.	Center of cavity of the beaks.
Cavity of shell	Shallow, white.	Deep, wide.	Rather shallow.	Deep.	[illegible]	Deep, wide.	Deep, wide.	Deep, wide.
Cavity of beak	Shallow, rounded.	Shallow, obtusely angular.	Shallow, rounded.	Very small.	Wide, subangulated.	Rather deep, subangular.	Small, obtusely angular.	Shallow, subangular.
Nacre	White, inclined to salmon in cavity of beaks.	White, iridescent.	White, iridescent.	White, iridescent.	Purple.	Purple, iridescent.	Purple, iridescent.	Purplish, iridescent.
Habitat	Ohio river.	Flint River, Ga. Neuse River, N. C.	Dougherty Co., Ga.	Chattahoochee River, Ga.	Ohio River.	E. Tennessee, N. Ga., N. Ala.	Kiokee Creek, Albany, Ga.	Big Prairie Creek, Ala.
Width	0.6 inch.	0.7 inch.	0.5 inch.	0.4 inch.	0.7 inch.	0.7 inch.	0.4 inch.	0.45 inch.
Height	0.8 inch.	0.8 inch.	1.0 inch.	0.6 inch.	0.8 inch.	0.8 inch.	0.7 inch.	0.62 inch.
Length	1.6 inch.	1.3 inch.	1.1 inch.	0.9 inch.	1.3 inch.	1.5 inch.	1.1 inch.	1.10 inch.

SYNOPSIS OF THE SPECIFIC CHARACTERS OF THE PARVUS GROUP.

GERMANUS.	CORVUNCULUS.	PULLUS.	VESICULARIS.	TEXASENSIS.	BAIRDIANUS.	BEALII.	MINOR.
Elliptical, somewhat inflated.	Elliptical, somewhat inflated.	Elliptical, somewhat inflated.	Elliptical, inflated.	Elliptical, sub-compressed.	Elliptical, slightly inflated.	Elliptical, somewhat compressed.	Elliptical, rather inflated.
Somewhat thick, thicker before.	A little thick, thicker before.	* * * *	A little thick, thicker before.	Rather thin, thicker before.	Rather thin, thicker before.	Slightly thickened, thicker before.	Thick, thinner behind.
Rather prominent, concentrically undulate.	A little prominent, concentrically undulate.	Slightly prominent.	Slightly prominent.	Slightly prominent, sub-concentrically undulate.	Slightly prominent, concentrically undulate.	A little prominent.	Rather prominent.
Short, thin, lightish brown.	Short, thin, brown.	* * * *	Rather long and thin.	Small, thin, yellowish-brown.	Small, thin, yellowish-brown.	Short, thin, dark brown.	Short, thin.
Dark brown, eradiate, transversely striate.	Blackish, eradiate; lines of growth distant.	Dark, olivaceous, wrinkled.	Dark olive, obscurely rayed, growth marks distant.	Dark olive, shining, obsoletely rayed, marks of growth distant.	Dark brown, obsoletely radiate, growth lines distant.	Dark brown or blackish, obscurely radiate, marks of growth distant.	Striate, nearly black.
Small, erect, compressed, crenulate, acuminate.	Small, erect, compressed, crenulate.	Oblique, single in one, double in the other valve.	Small, sulcate, somewhat compressed, double in both valves.	Small, erect, crenulate.	Small, erect, acuminate, crenulate, double in both valves.	Small, compressed, crenulate, pointed, double in both valves.	Rather large.
Thin, somewhat curved.	Rather long, slightly curved.	* * * *	Rather long, lamellar, nearly straight,	Long, lamellar, somewhat curved.	Long, lamellar, somewhat curved.	Very long, slightly curved, lamellar.	Small, curved.
Distinct, small, well impressed.	Distinct, small, well impressed.	* * * *	Distinct, small, well impressed	Distinct, small, well impressed	Distinct, small, somewhat impressed.	Distinct, rather large, moderately impressed.	Distinct.
Confluent, slightly impressed.	* * * *	* * * *	Confluent, rather large, moderately impressed.	Confluent, slightly impressed.	Confluent, slightly impressed.	Confluent, slightly impressed.	Confluent.
Center of cavity of beaks.	Center of cavity of the beaks.	* * * *	Center of cavity of the beaks.	Across the cavity of the beaks.	Across the cavity of the beaks.	Across center of cavity of the beaks.	Center of cavity of the beaks,
Rather deep, wide.	Deep, wide.	Very capacious.	Deep, wide.	Somewhat deep, wide.	Small, wide.	Shallow, wide.	Deep.
Shallow, obtusely angular.	Shallow, obtusely angular.	Very capacious.	Shallow, obtusely angular.	Shallow, obtusely angular.	Shallow, obtusely angular.	Shallow, obtusely angular.	Rather deep, angular.
Purplish, iridescent.	Purple, iridescent.	Chocolate purple.	Whitish, iridescent.	Bluish, very iridescent.	White, very iridescent.	White or pale salmon, iridescent.	Pearly white, iridescent.
Coosa River, Ala.	Swamp Creek, Whitfield Co., Ga.	Wateree River, S. C., Warm Spa, N. C.	Lake Ocheechobee, Fla.	DeWitt Co., Texas.	Devil's River, Texas.	Leon Co. and Rutersville, Texas.	Lakes Monroe and George, Fla.
0.55 inch.	0.5 inch.	* * * *	0.5 inch.	0.5 inch.	0.4 inch.	0.6 inch.	0.4 inch.
0.82 inch.	0.7 inch.	* * * *	0.7 inch.	0.8 inch.	0.7 inch.	1.0 inch.	0.6 inch.
1.40 inch.	1.2 inch.	* * * *	1.3 inch.	1.4 inch.	1.2 inch.	1.7 inch.	0.9 inch.

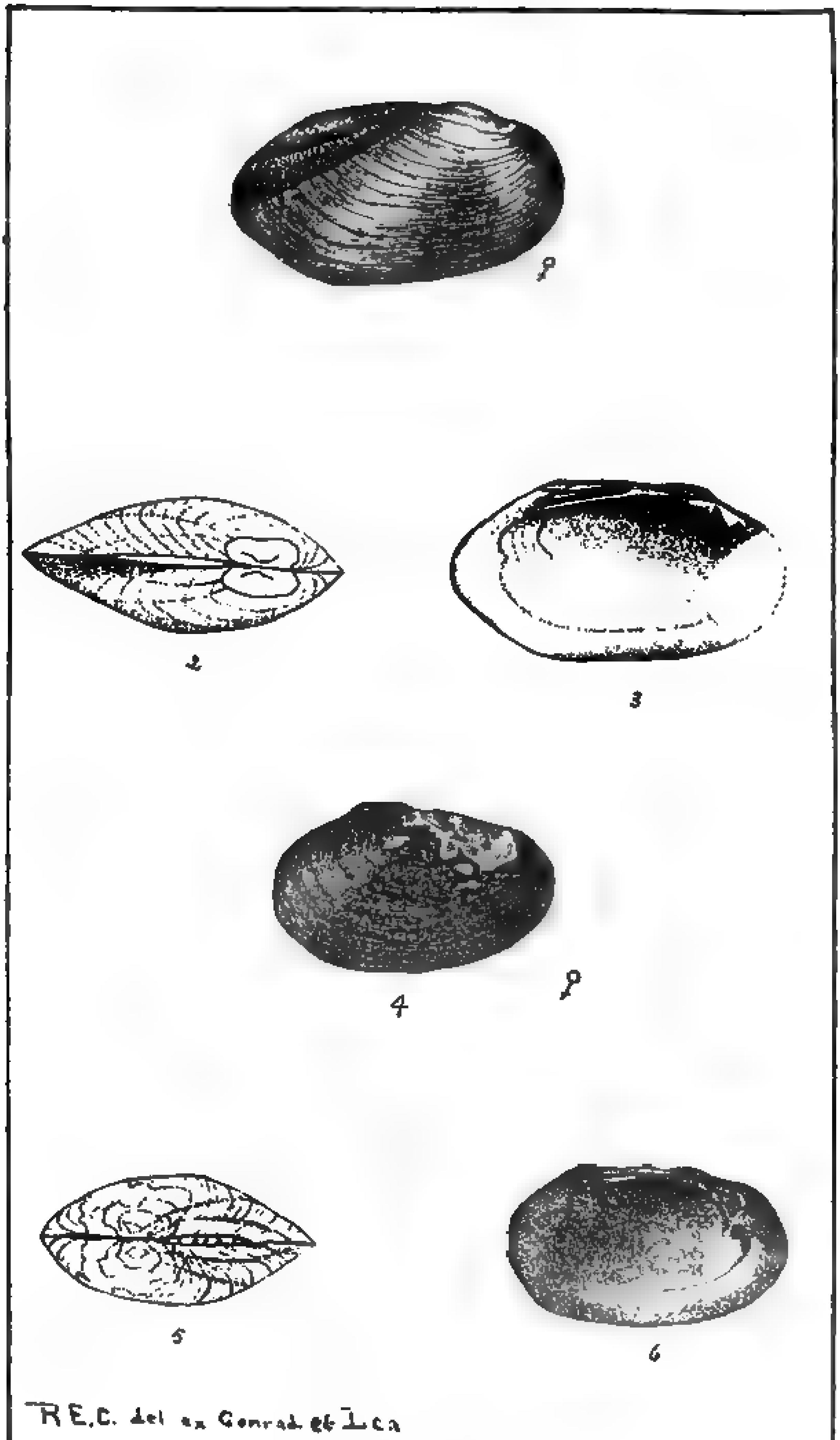
ADDITIONAL NOTE.

Since the work on this group of Unios was completed I have had the opportunity to re-examine a carefully prepared paper by Mr. Chas. T. Simpson on the "Unionidæ of Florida." I must dissent from some of the conclusions Mr. Simpson reaches, though in the main he is, beyond question, correct. That author places *Unio lepidus* Gould and *Unio trossulus* Lea in the *parvus* group. Both these shells are here out of place. *Unio trossulus* has the fine concentric undulations on the umbones which are so characteristic of many Unios typified by *Unio fallax*, *Unio lienosus et cetera*. Both Lea's figure and his description do not permit that this form go into the present group. The character of the radiation, as given by Mr. Simpson in his very poor outline figure of *Unio lepidus* places it elsewhere, for if there is any such thing as a characteristic in the *parvus* group its radiation, when present, is very remarkable and quite uniform. There is no doubt that *Unio trossulus* and *Unio lepidus* are synonyms. The paper of Mr. Simpson is to be commended as marking a distinct advance in the study of the southern representatives of this great family. It appeared in volume XV of the Proceedings of the United States National Museum, 1892, and should be in the hands of every student of *Unio*.

The proofs of this article reached me when consultation of my library on one or two points suggested by careful re-reading was impossible. The synonymy of *Unio parvus* should have included the following:

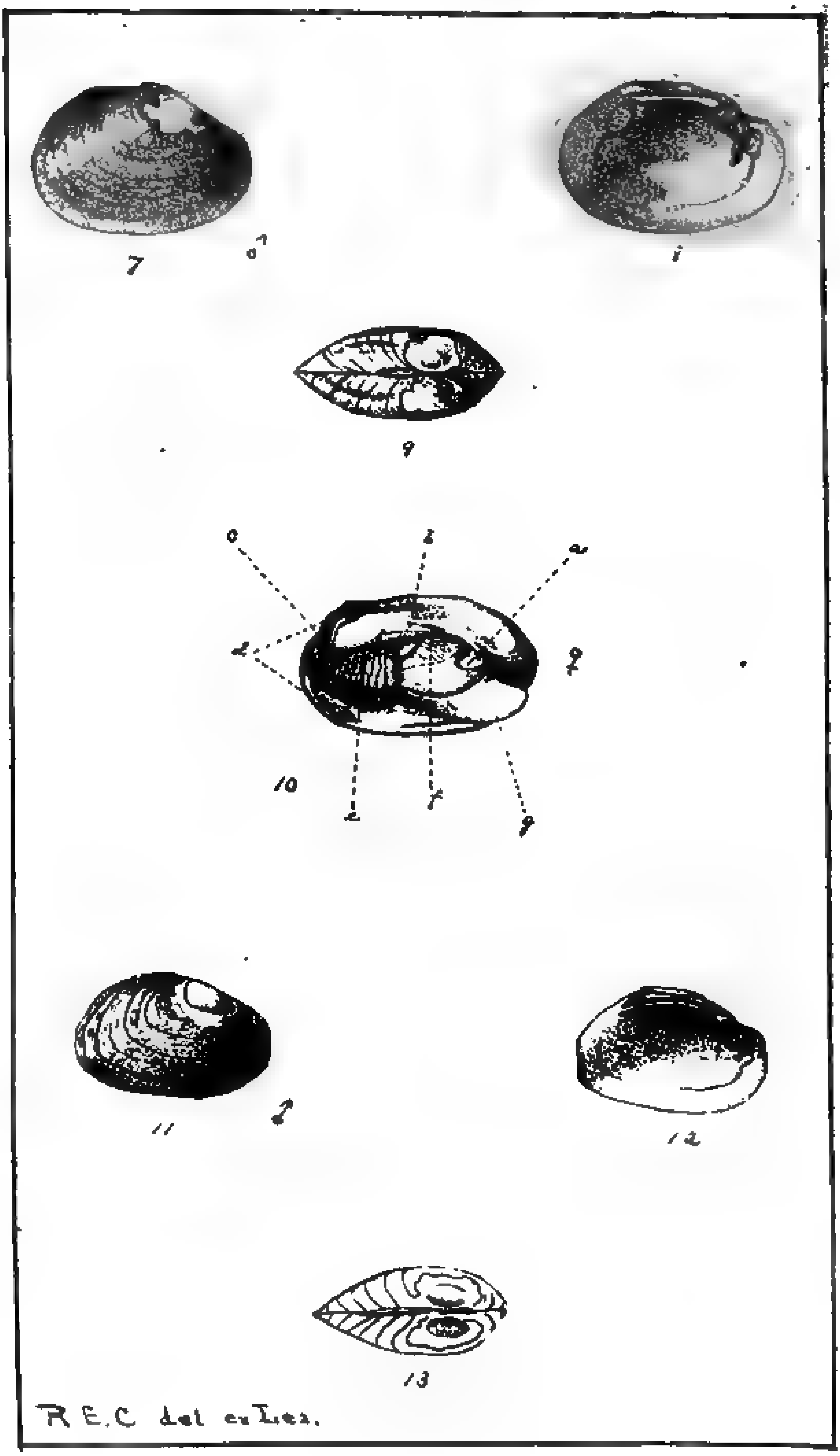
Unio singleyanus Marsh. Ephemerally described in the Joliet Weekly, a newspaper of Illinois, May, 1891. See also the "Nautilus," Vol. V, p. 29; Simpson, "Notes on Florida Unionidæ," Proc. U. S. Nat. Mus., Vol. XV, pp. 426, 427, pl. LXVIII, figs. 4, 5 (1892). Without doubt a synonym for Lea's *Unio marginis*, itself a southeastern representative of *Unio parvus*.

Plate I.



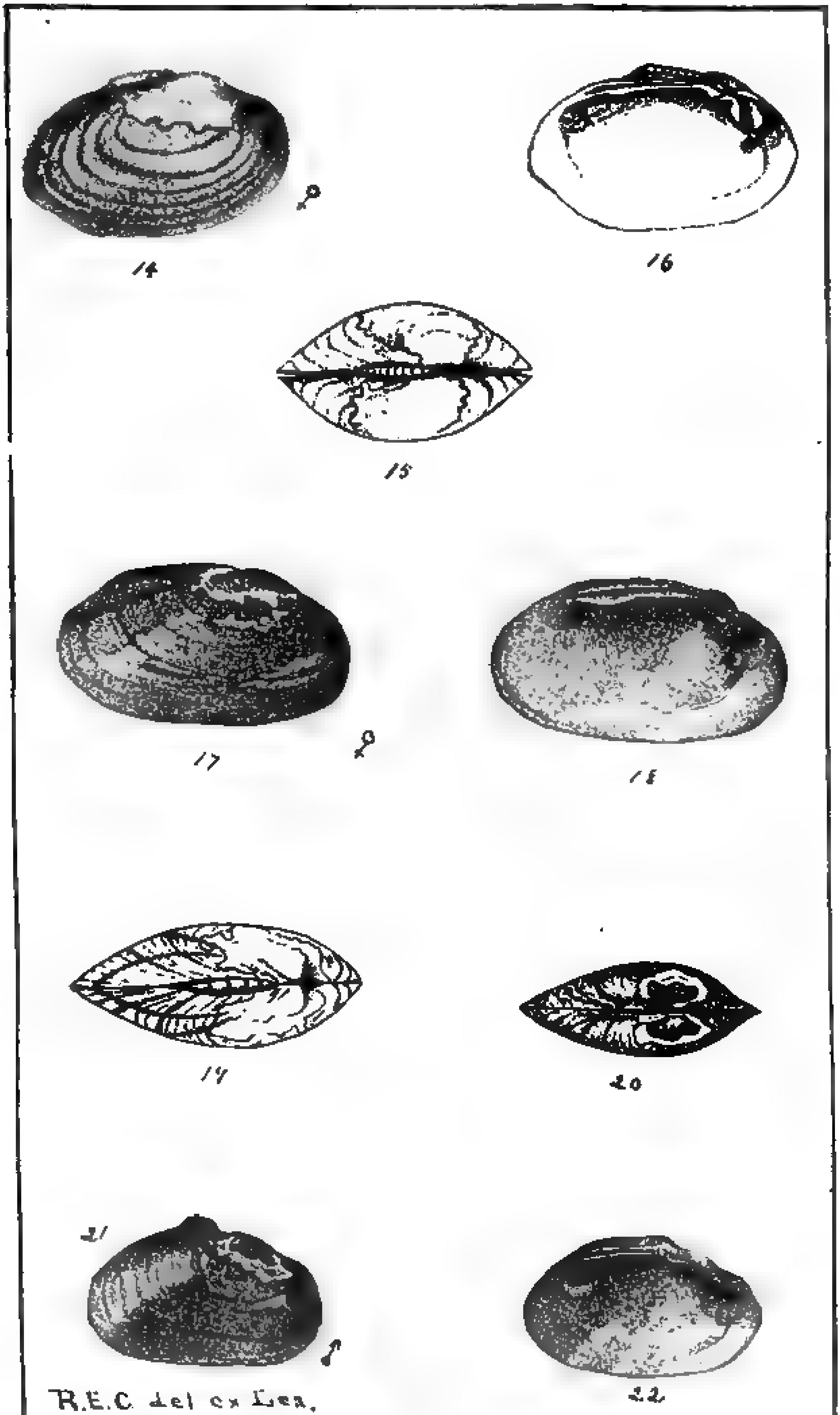
CALL, ON PARVUS GROUP OF UNIO.

Plate II.



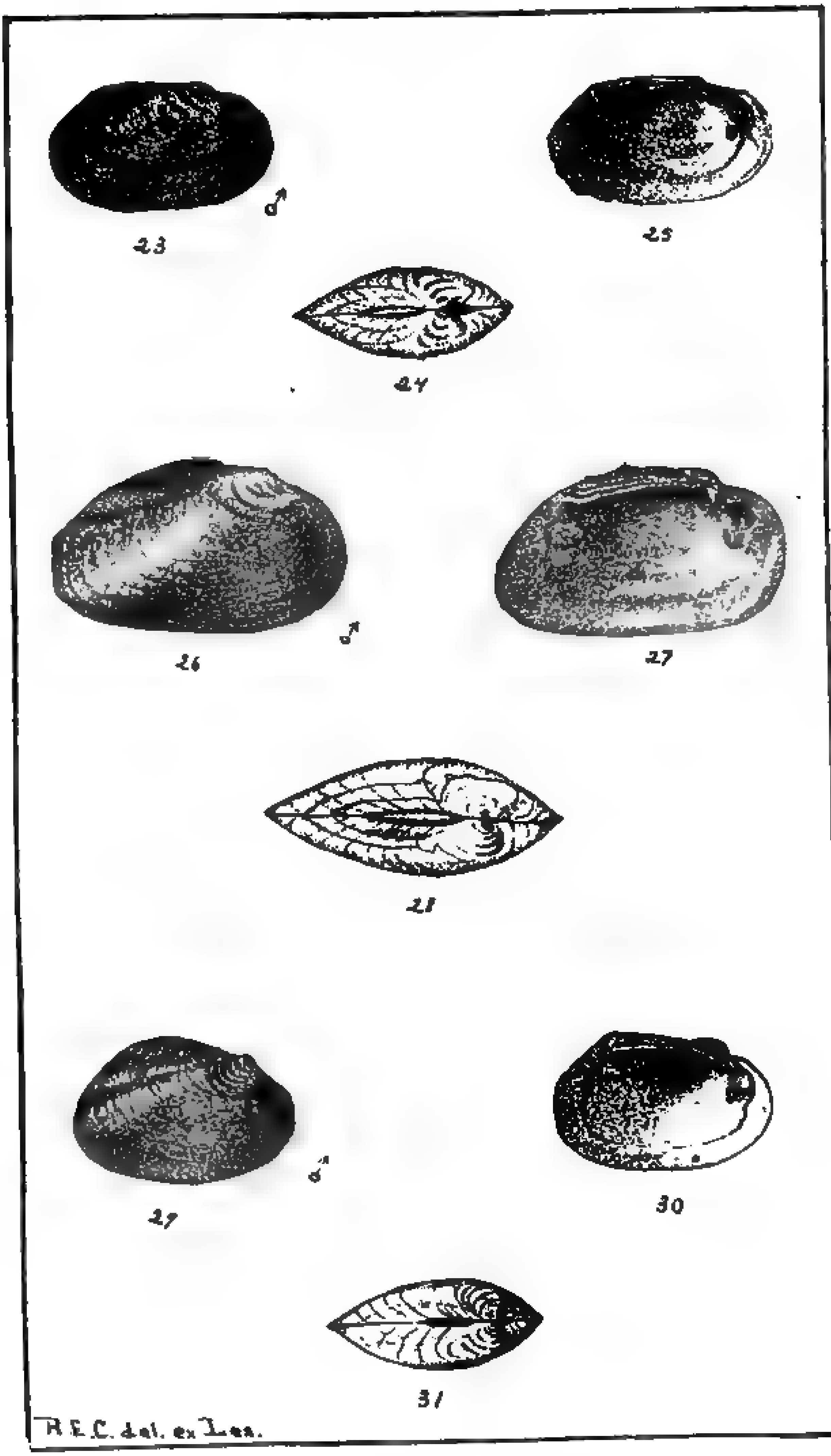
CALL, ON PARVUS GROUP OF UNIO.

Plate III.



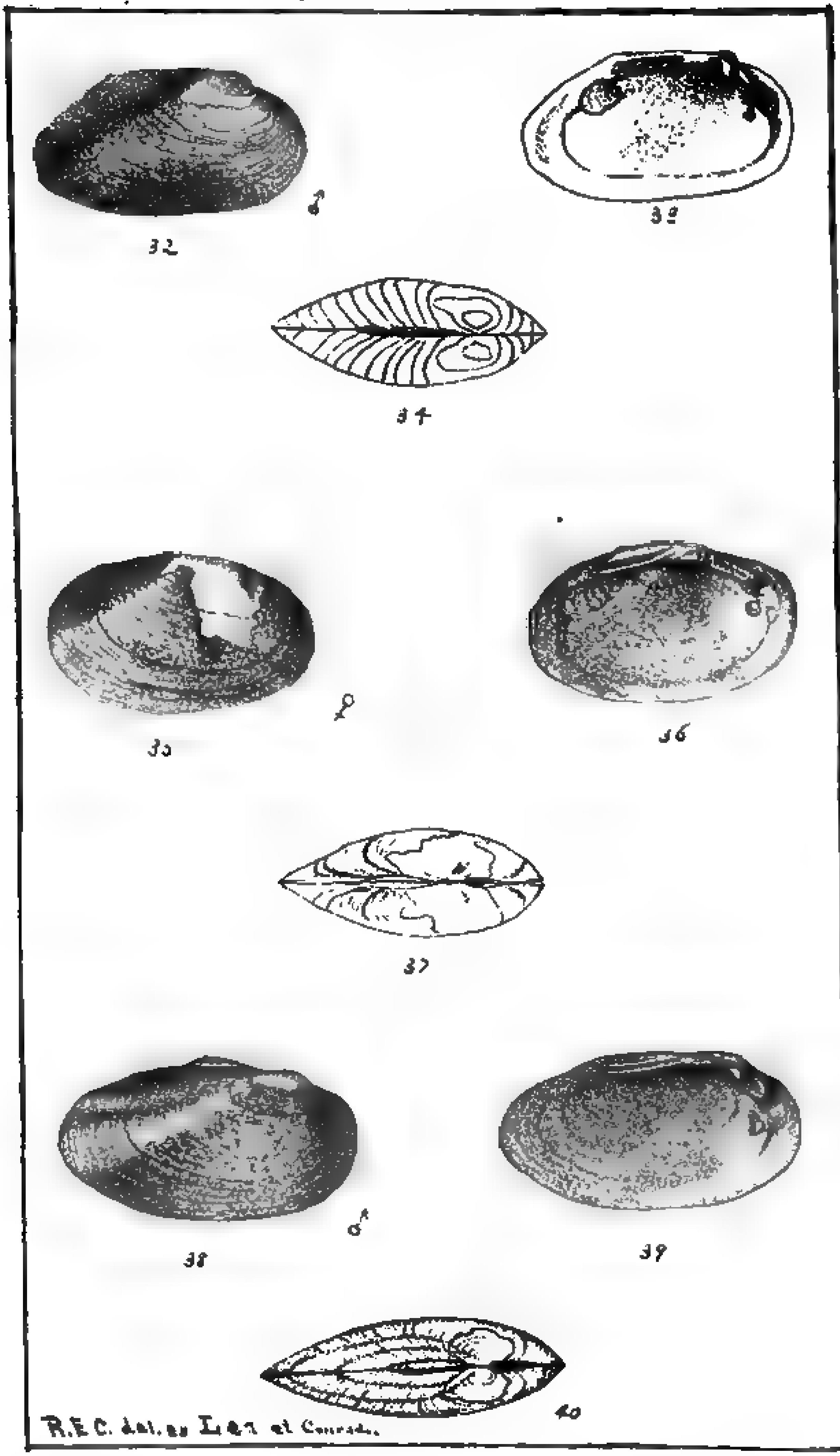
CALL, ON PARVUS GROUP OF UNIO.

Plate IV.



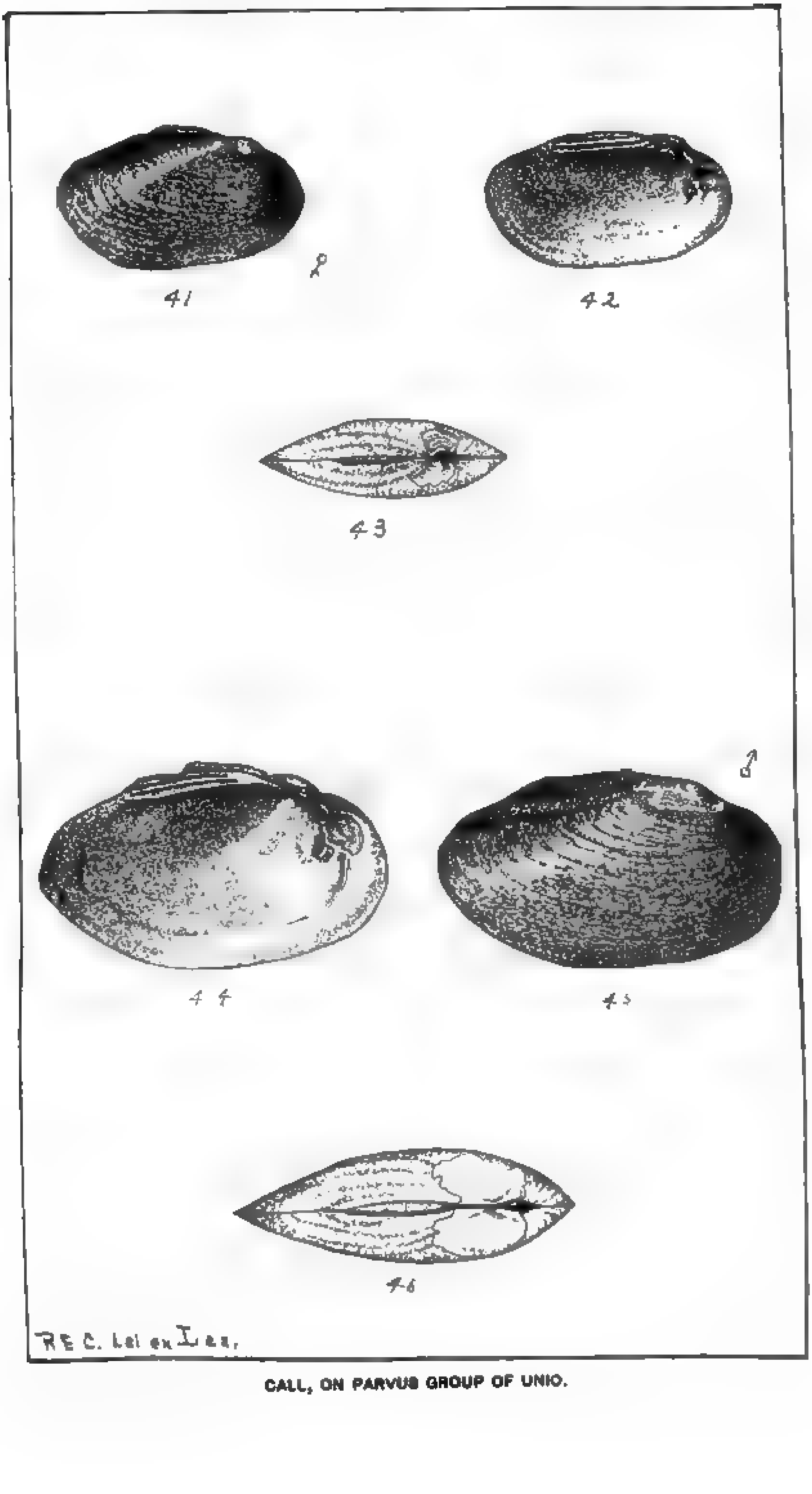
CALL, ON PARVUS GROUP OF UNIO.

Plate V.



CALL, ON PARVUS GROUP OF UNIO.

Plate VI.



CALL, ON PARVUS GROUP OF UNIO.

THE FISHES OF THE MISSOURI RIVER BASIN. BY BARTON W. EVERMANN AND J. T. SCOVELL.

In 1892 and again in 1893 Dr. Evermann made extended investigations in Iowa, South Dakota, Nebraska and Wyoming for the purpose of selecting a site for a fish-cultural station somewhere in that region. In 1891 he had made similar investigations in Montana and Wyoming and primarily for the same purpose.

While engaged in this work we examined a great many streams and made large collections of fishes representing a great many localities.

Studying these collections very naturally led to a consideration of the entire fish-fauna of the Missouri basin, and it is with some of the interesting features of this fauna that the present paper deals. That we may understand more clearly the distribution of the fishes a few words concerning the characteristic features of the basin may not be out of place.

The Missouri River Basin. The Missouri is the longest river in North America. Its headwaters are among the Rocky Mountains of Montana, Wyoming and Colorado. At numerous places its sources are but a few miles from those of the Saskatchewan, the Columbia and the Colorado. In northwestern Montana are the sources of Milk River which are said to be connected directly with those of the Saskatchewan, while only a few miles to the westward the drainage is into Flathead River and thence into the Columbia. In southwestern Montana the headwaters of the Big Hole, Beaverhead, Red Rock and Madison on one hand closely approach those of the Bitter Root, Salmon and Snake on the other. In northwestern Wyoming, just south of the Yellowstone National Park, the headwaters of the Columbia and Missouri actually unite in Two-Ocean Pass, forming a continuous waterway from the mouth of the Columbia to that of the Mississippi.*

In Wyoming the Sweetwater, a tributary of the North Platte, and in Colorado the South Platte, rise within a few miles of streams which are tributary to the Colorado of the west.

The headwaters of these various tributary streams are 8,000 to 14,000 feet above sea level. Gallatin, Montana, where the Jefferson, Madison and Gallatin rivers unite to from the Missouri proper is 4,132 feet altitude, the sources of Madison River are over 8,300 feet above the sea, while Two-Ocean Pass is about 8,200 feet.

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*For a full description of this phenomenon and its bearing upon the distribution of fishes see Evermann, in Popular Science Monthly, for June, 1895.

The mouth of the Missouri River is about 400 feet above sea level; the total .all of this river is over 7,000 feet, or 3,732 feet between Gallatin and the Mississippi. The length of the Missouri proper is given as 3,000 miles; add to this the length of Madison River and we have 3,230 miles, which may properly be regarded as the total length of the Missouri. Among the important tributaries may be named Milk River; Jefferson Fork, 140 miles; Gallatin Fork, 170 miles; Yellowstone River, 1,100 miles; Platte River, 1,250 miles (including the North Platte); and the Kansas River, 900 miles (including the Smoky Hill Fork). The area drained by this great river is given as 518,000 square miles. This includes the entire State of Nebraska, all of South Dakota, except a few square miles in the northeast corner; nearly all of Montana, North Dakota and Wyoming, about half of Kansas, more than half of Missouri, and large parts of Iowa and Colorado.

The Missouri basin may very properly be divided into three parts, viz., the western or mountainous, the middle or plains portion, and the eastern or region of deciduous trees.

The mountainous belt includes western Montana, northwestern and central Wyoming, and a small portion of central Colorado. This includes the portion with an altitude of about 4,000 feet or over, and is the region of coniferous forests and swift, clear and cold mountain streams.

The middle belt includes most of northern and eastern Montana, a part of eastern Wyoming and Colorado, and, excepting a narrow strip along their eastern edge, all of the Dakotas, Nebraska and Kansas. This is, in its general features, a broad, level plain, with slight irregularities here and there. It is a region without forests, and over much of its surface not much vegetation of any kind is found. The only timber of any importance is the narrow strip of cottonwoods and willows covering the bottom lands along the streams. The western and central portions of this belt are very barren, in places even desolate, particularly in the Bad Lands, or Mauvais Terre of South Dakota, and parts of North Dakota, Wyoming, Montana and Nebraska. These tertiary beds are of great thickness, usually full of alkali, and very easily eroded.

The Black Hills constitute a mountainous island of evergreen forests and beautiful, clear, cold streams in this desert plain, but need not concern us in the consideration of the basin as a whole. The eastern part of this belt receives more moisture and is a typical prairie region, but its streams are slow, shallow and shifting, still carrying much solid matter in suspension from the region to the westward.

The third or eastern belt embraces a narrow strip along the eastern border of South Dakota, Nebraska and Kansas, and the portions of Iowa and Missouri lying

within the Missouri basin. This is essentially a region covered with forests of deciduous trees. It is true that some parts of it are prairie, but the soil contains little or no alkali, and the small streams having their rise in it are fairly clear and pure.

In the mountains at the headwaters of the various tributary streams there is an abundance of rainfall in summer and snow in winter; as a rule the mountains were originally heavily timbered and the moisture was therefore conserved and fed out slowly during the season of drought. This is still true in general, but the reckless destruction of the forests in many places is having its effect upon the streams.

After leaving the mountains the tributaries of the Missouri, with scarcely an exception, enter the broad treeless plain of the middle belt. Here the alkali soil erodes easily, the current becomes slower, the bed broadens, the channel shifts from year to year, and the water becomes warmer and often of the consistency of thin soup. This is the character of all the larger streams as they pass through this middle belt, and the character of the water is the same in all the smaller streams which start in this belt.

The Missouri Basin as a whole, however, is a country whose soils erode with unusual ease and, after getting out of the mountains and upon the plain, few of the streams are ever really clear The Missouri River is always carrying vast amounts of solid matter in suspension and justly deserves the name "Big Muddy." The channels of the Missouri and all the larger tributaries are constantly changing and shifting the beds of the streams.

THE FISHES OF THE MISSOURI RIVER BASIN.

All this, of course, has its effects upon the fish fauna of this river system. Each of the three belts possesses a fish fauna differing very materially in the aggregate from that of each of the other belts.

The total number of species and subspecies of fishes now recognized from the entire Missouri basin is 143. These are distributed among 24 families and 68 genera. The families with large numbers of species are:

The Cyprinidae, with 50 species.

The Percidæ, with 20 species.

The Catostomidae, with 16 species.

The Centrarchidæ, with 12 species.

The Siluridæ, with 10 species.

Only 10 species are characteristic of the western belt, the most characteristic ones being the cut-throat trout, Williamson's whitefish, the blob, the grayling, the long-nosed sucker, Jordan's sucker, and the western dace.

Only 45 species are known from North Dakota, Montana, Wyoming and Colorado. On the other hand, Missouri and the small part of Iowa drained by the Missouri, furnishes 94 species, or, if we include the narrow timbered and abundantly watered strip of eastern Kansas, Nebraska and South Dakota, we have about 100 species occurring in this eastern or lower belt of the Missouri Basin. The middle belt has such characteristic species as *Platygobio gracilis*, *Hybopsis gelidus*, *Hybognathus nuchalis evansi*, and the like. Few if any of these are confined to this belt, but they probably all extend more or less into the lower and upper belts.

In the lower portion of the middle belt is found the limit in the western extension of spiny-rayed fishes. West of the 96th meridian, which is approximately the eastern boundary of Nebraska and the Dakotas, not over a dozen species of spiny-rayed fishes are known to occur. This fact becomes interesting when we recall that a single small creek in Indiana (Bean Blossom Creek, Monroe County*), is known to contain not fewer than thirty-five species of spiny-rayed fishes, and from the streams of Indiana alone we know at least fifty-one species of that group—nearly as many as the total number of species found in the entire fish-fauna of the Missouri basin west of the 98th meridian.

In the Missouri itself and in its larger tributaries are found such large river species as *Polyodon spathula*, *Scaphirhynchus platorynchus*, *Leptops olivaris*, *Ictalurus punctatus*, species of *Ictiobus*, and the like; but in the smaller streams *Catostomus*, *Hybognathus* and *Notropis* are the principal genera represented. *Micropterus*, *Perca*, *Lepomis*, and *Etheostoma* are not rare on the eastern edge of this region, but they become more and more rare as we go westward and very soon disappear altogether. *Perca* has not yet been found west of Mitchell, S. D., 98° west; *Micropterus* has not been found west of Ravenna, Neb., 98° 30′ W., and it is not likely that it occurs naturally even that far west.

Of the four darters whose range extends farthest west in this basin, *Boleosoma nigrum* reaches only to Mitchell, S. D., *Hadropterus aspro* to Ewing, Neb., 98° 20′ W., *Etheostoma iowae* extends still further west, having been found by us at Valentine, Neb., 100° 30′ W., while *Boleichthys exilis*, a somewhat doubtful species, was found even a little farther west in North Dakota.

The Flat-headed Chub is pre-eminently the characteristic fish of the shallow, alkali streams of the middle Missouri basin, and shows better than any other the

* Eigenmann and Fordice, Proc Phil. Acad. Sci. 1885.

peculiar bleaching effect of the alkaline waters of that region. The fishes are all reduced to a nearly uniform pale or faded appearance. Except those found in the headwaters above the alkali, they seem to be almost wholly without pigment cells of any kind. Perhaps the most extreme case of bleaching is that of *Platygobio gracilis*, which, of all American fishes, seems to be the one most perfectly adapted to life in these alkaline streams.

An examination of the literature shows that seventy-four nominal species have been described as new from Missouri basin localities. These seventy-four names represent fifty-one species as now understood, but all but twenty-eight of the seventy-four nominal species had already been described, so only twenty-eight of them were really new. Indeed, we are inclined to think that a little closer investigation will show at least eleven of these twenty-eight to have been not new, so that of the seventy-four fishes which have been described as new from the Missouri basin only seventeen, or about 23 per cent., were really so.

TABLE GIVING NAMES OF DESCRIBERS OF MISSOURI BASIN FISHES, THE NUMBER DESCRIBED BY EACH, AND THE NUMBER OF EACH WHICH STILL HOLD.

AUTHORS.	No. of Species Described.	No. Which Still Hold.
Agassiz	3	1
Abbot	4	0
Cope	21	8
Duméril	3	0
Evermann	1	1
Evermann and Cox	2	2
Gilbert	2	1
Garman	2	1
Gill	5	1
Girard	20	8
Hay	3	0
Jordan	4	1
Jordan and Evermann	1	1
Meek	2	2
Milner	1	1
Total	74	28

Recent Investigations Concerning the Redfish, Oncorhynchus nerka, at its Spawning Grounds in Idaho. By Barton W. Evermann and J. T. Scovell.

Of the 130 or more families of fishes now recognized as constituting the fish-fauna of North America, the one of greatest and most general interest is the *Salmonidae*, the family to which belong the whitefish, the salmon, and the trout.

Whether we consider beauty of form and color, activity, gaminess, quality as food, or abundance and size of individuals, the different members of this family stand easily with the first among fishes.

Confined to the north temperate and arctic regions, they abound wherever suitable waters are found. In North America alone no fewer than sixty-two species are found. Some of these species are confined to the smaller rivers and running brooks, entering lakes or the sea as occasion serves, but not habitually doing so. Such are some of the species of trout of the genera *Salvelinus* and *Salmo*. Others again are lake fishes, approaching the shores or entering the tributary streams only at spawning time and then retiring again to deeper waters. These are the whitefishes and lake herrings.

Then there is another group made up of species that are marine and anadromous, living and growing in the sea, but entering fresh waters at spawning time. Such are the five species of salmon of our west coast.

From California to northern Alaska and across to Kamchatka are found five species of true salmon of the genus *Oncorhynchus*, viz.:

1. The Hump-back salmon, *O. gorbuscha*,
2. The Dog salmon, *O. keta*,
3. The Silver salmon, *O. kisutch*,
4. The Blue-back salmon, *O. nerka*, and
5. The Chinook salmon, *O. tschawytscha*.

The most interesting and by far the most important of the five are the Chinook and the Blue-back; and it is to the last of those two species that this paper is devoted.

In Kamchatka and Alaska this species is known as the Red salmon and is commercially worth more than all the other salmon of Alaska combined. It here ranges in weight from five to eight pounds, and in late summer and early fall they enter the rivers and lakes of Alaska in myriads at spawning time. In the Columbia River it is called the Blue-back salmon and, next to the Chinook, is the most valuable fish of that river.

The Blue-backs enter the Columbia along with the Chinooks early in the spring, the height of the run being in the month of June; and the catch in the lower Columbia amounts to several hundred thousand fish annually. Such as escape the labyrinth of nets, traps and wheels which for miles literally fill the lower Columbia, pass on to their spawning grounds. We do not yet know just where all their spawning grounds in the Columbia basin are located, but we do know that there are important ones in the inlets of Wallowa Lake in Oregon, and Payette Lake and the Redfish Lakes in Idaho.

It was not, however, until 1894 that any naturalist visited these lakes at the spawning time and made any study of the spawning habits.

In September of that year we made a brief visit to Alturas and Pettit lakes and Big Payette Lake, where we found this salmon spawning.

Big Payette Lake is situated near the head of Payette River about 120 miles northeast from Weiser, Idaho. Alturas and Pettit lakes are two of a group known as the Redfish Lakes, lying among the eastern spurs of the Sawtooth Mountains, forty-five to seventy-five miles northwest from Ketchum, Idaho, the nearest railroad station. These Redfish lakes are really the headwaters of Salmon River, the principal tributary of the Snake, and their distance by water from the sea is more than a thousand miles.

The investigations of 1894 showed that the vicinity of those lakes afforded excellent facilities for studying the habits of the salmon which spawn there, and it was decided to visit them again in 1895.

It should be here stated that the Blue-back salmon which enter the Columbia River are no longer known by that name when they reach their spawning grounds, but are known as Redfish. When they enter the river from the sea they are a clear, bright blue above and silvery on the sides, but when they reach their spawning grounds they have become more or less red, especially the males, which are often a bright scarlet red on the back and sides, the head being a light olive-green. At these Idaho lakes two forms of the Redfish have long been known to occur, a large form weighing four to eight pounds and corresponding to the regular Blue-backs taken in the mouth of the Columbia; the other is a small form weighing almost invariably a half pound each and not corresponding to any salmon ever taken in the lower Columbia. Structurally it does not appear to differ from the large form in anything except size, and the two forms are regarded as being specifically identical.

But a number of questions concerning this fish were veiled in more or less obscurity, among which may be mentioned the following:

1. Do the Redfish which spawn in the inlets of the Idaho lakes really come up from the sea, and when do they first arrive?

2. During the spawning season the Redfish are observed to have their fins more or less worn or frayed-out and to have sores upon the body. Are these mutilations received on the spawning grounds, or are they injuries incident to the long and perilous journey from the sea?

3. What are the habits of the Redfish during spawning time?

4. What becomes of them after done spawning? Do they return to the sea, to the lakes, or do they all die?

In order to answer as many of these questions as possible, it became at once evident that an extended series of observations at one of the lakes would be necessary. A camp was therefore established at Alturas Lake last summer on July 20, and the observations begun then were carried on continuously until September 24.

Alturas Lake is situated at an altitude of 7,200 feet, between two immense glacial moraines extending downward from the eastern spurs of the Sawtooth Mountains. It is about two miles long, four-fifths of a mile wide, and has a maximum depth of 158 feet. Its inlet is a small mountain stream about eight miles long, and thirty feet wide at the mouth. The outlet of Alturas Lake is somewhat larger, and after flowing through Perkins Lake (a small lake about a half mile below) enters Salmon River Valley. After a course of about five miles to the northeast, Alturas outlet joins Salmon River.

Just above the lake on either side of the inlet tower extremely rugged mountains whose peaks are 9,000 to 11,000 feet above the sea, and the scenery is as wild as any to be found in America.

In order to study the Redfish effectually, we set gill nets in the outlet and in the inlet and examined them from day to day. The nets in the outlet would tell us when the fish arrive from below on their way to the spawning grounds. The nets in the inlet would tell us when the fish run up out of the lake to their spawning beds, and also whether they return to the lake after done spawning.

Without going too much into detail, it will suffice to say that daily observations of the lake, outlet and inlet, were made, and the nets, though not kept continuously set, were so regulated as to assist in solving as many as possible of the problems involved.

Not a single Redfish was ever caught in any of the nets in the outlet. If they come up from the sea, they had reached Alturas Lake before July 20, when our nets were set.

On July 24 four small Redfish were caught on the net in Alturas inlet, and in a day or two they were abundant in this stream. Evidently, therefore, they had entered the lake at some date prior to July 20, and had remained in it until the evening of July 23 when they first entered the inlet.

Beginning with July 23 the fish continued to enter the inlet until early in September. During this time at least 2,000 Redfish, only about a dozen of which were of the large form, entered this small creek. Hundreds of these were examined as they were running up into the inlet from the lake, and not one of them showed any sores, frayed-out fins, or mutilations of any kind. Toward the close of the spawning season there was scarcely a fish whose fins were not more or less worn out (frequently the caudal was entirely gone) and whose back or sides were not sore. And we were able to see how these mutilations were received.

During the spawning period there is a rather definite pairing off of the sexes. The spawning beds are usually in very shallow water on a bottom of fine gravel and sand. While spawning, this gravel and sand is moved about a good deal and made up into so-called nests, both sexes taking part in the work. The gravel is moved about by the fish striking it with the tail, or by pushing against it with the lower fins, or sometimes even with the dorsal fin and the back. The gravel is moved by a rapid, quivering movement of the body as the fish swims over the nest; then she circles around down stream a few feet and approaches the nest to repeat the act again. The male follows closely behind the female, and frequently moves the gravel in the same way.

The fish move about to some extent in the inlet, but there is no evidence that they ever try to return to the lake. Our nets caught a good many from the upper side, but they were nearly all dead or dying fish which had been carried down by the current, and were only slightly gilled or simply lodged against the upper side of the net. We saw no evidence whatever indicating any tendency to return down stream, and it is not easy to believe that any fish, so seriously mutilated as these all are at the end of the spawning season, could survive. On September 5 we counted about 1,000 fish in Alturas inlet; two weeks later all had died but about 150, and a week later practically all had died.

We consider it, therefore, absolutely proved that the Redfish which spawn in the inlets of the Idaho lakes spawn only once and then die, and that the mutilations are received on the spawning beds.

A New Habitat for Gastrophilus. By A. W. Bitting.

The genus *Gastrophilus* contains two well known species, *Gastrophilus equi* and *Gastrophilus haemorrhoidalis*. These parasites are commonly known as bots and inhabit the stomach and duodenum of the horse.

The life cycle is as follows: The female deposits her eggs upon the ends of the hairs upon the fore limbs or some other part of the body that the horse is likely to touch with his mouth in fighting flies. The eggs hatch and the lid breaks open to permit their escape in from five to fifteen days. They attach themselves to the lips or tongue when the host is fighting flies and soon find their way into the stomach or interior part of the duodenum. Here they pass a period of development lasting about seven months. Their food consists of the nutriment found in solution in the juices of the stomach. They escape from the body with the excrement, pass a pupa state in the ground to emerge in a short time as adult.

The particular observation to be recorded here is the finding of this parasite in the alveoli of the horse's teeth.

Last September there were an unusual number of cases of caries of the teeth at the clinics.

While extracting teeth six larvae were obtained attached to the tissues of the teeth or alveolar cavity. They were alive and active. They were about three centimeters from the surface of the gums and there was no visible point for entrance.

The question remains how did they get to their destination and how did they accommodate themselves to take nutriment from the blood when it is believed that they are dependent upon the juices of the stomach?

Are they a factor in producing caries of the teeth?

Second Contribution to a Knowledge of Indiana Mollusca. By R. Ellsworth Call.

The sources of information on which the facts stated in this brief paper are based are various. No single source has availed largely in determining the locality references that are given, though the collection in the Geological Museum, in the State Capitol, has furnished the greater number. All the rest have been contributed by specimens submitted through several gentlemen practically interested in the work of the biological survey of the State. For this aid thanks are

due W. S. Blatchley, State Geologist; Dr. J. T. Scoville, Terre Haute High School; Dr. C. H. Eigenmann, State University, Bloomington; Mr. Harry Dodge, Charleston, Indiana, and Mr. Charles Dunn, Chicago.

The specimens which have been seen are mainly the most common forms. In some few cases they have been found to be widely distributed over the State; others are, apparently, confined to the Ohio and its principal tributary stream, the Wabash. North of the divide that separates the Ohio and lake drainages fewer forms of *Unionidæ* occur, but the *limnæid* fauna appears to represent both an increased number of individuals and of species. The land shells of the Ohio drainage are both more abundant and varied. But no really final generalizations can yet be ventured in the absence of extended collecting and large numbers of shells—a condition which the present activity of members in this branch of the State's biological survey indicates to be very remote. The facts collected for the year past are the following:

Land Mollusca.

Mesodon albolabris Say.

Charleston, Terre Haute, Indianapolis, New Albany.

Mesodon clausus Say.

Vigo County, Indianapolis, Peru.

Mesodon elevatus Say.

Terre Haute, Indianapolis, Corydon.

Mesodon exoletus Binney.

Vigo County, Indianapolis.

Mesodon multilineatus Say.

Terre Haute, Indianapolis.

Mesodon profundus Say.

Charleston, Indianapolis, Terre Haute.

Mesodon thynoides Say.

Vigo County, Indianapolis, Charleston.

Patula alternata Say.

Vigo County, Charleston.

Patula solitaria Say.

Vigo County, Charleston.

Patula perspectiva Say.

Vigo County.

Patula striatella Anthony.

Vigo County.

Zonites arboreus Say.

Vigo County, Bloomington, Charleston.

Zonites ligerus Say.

Vigo County.

Zonites gularis Say.

Charleston.

Zonites fuliginosus Griffith.

Gibson County.

Triodopsis fallax Say.

Vigo County, Indianapolis.

Triodopsis inflecta Say.

Charleston, Vigo County.

Triodopsis appressa Say.

Vigo County, Indianapolis.

Triodopsis palliata Say.

Vigo County.

Triodopsis tridentata Say.

Charleston, Vigo County.

Tebenophorus dorsalis Binney.

Vigo County.

Limax campestris Binney.

Vigo County, Turkey Lake.

The "slugs" or shell-less terrestrial mollusks of Indiana are hardly known. Very few collections contain any representatives. Inasmuch as they do not appeal to the conchologist and are rather difficult of preservation, requiring alcoholic methods, they have been neglected. They promise useful facts if particular attention is directed to their systematic collection. They are to be sought under chips, boards, logs, flat rocks, bark, sidewalks, in cellars and about barns and other outhouses in damp situations. A track of dried mucus will often lead one to their hiding place, if carefully traced. They should receive especial attention from the collectors of the survey.

Stenotrema monodon Rackett.

Vigo County.

Stenotrema hirsutum Say.

Vigo County.

Macrocylis concava Say.

Charleston, Indianapolis, Terre Haute.

Succinea avara Say.

Vigo County.

Succinea obliqua Say.

Vigo County.

FRESH WATER UNIVALVES.

Bulinus hypnorum Linnæus.

Coffee Chute, Gibson County.

Limnæa caperata Say.

Vigo County.

Limnophysa humilis Say.

Very abundant on marshy banks of the Ohio, in springs at New Albany; found in 1894 in myriads.

Limnophysa reflexa Say.

Ponds, Vigo County.

Physa gyrina Say.

Marion County; probably found everywhere in the State; exceedingly abundant in pools on the Falls of the Ohio.

Helisoma trivolvis Say.

Vigo County.

Planorbella campanulata Say.

Ponds, Vigo County; Lake Maxinkuckee.

Pleurocera subulare Lea.

Wabash River, Vigo County.

Plurocera canaliculatum Say.

Very abundant on the Falls of the Ohio; on muddy banks of the Wabash River, at Terre Haute, occurs in myriads. A large number of specimens were collected in October, 1895, at the last named locality, which present a wide range of variation, both in the characteristic grooving of the body-whorl and in coloration. Many specimens occurred without any indication of a groove; in others the angle, which is found along the lower border of the body-whorl, may be sharp, or obtuse, and is frequently thickened at intervals, constituting a character that makes a number of specimens approximate *Pleurocera moniliferum* Lea. Any one of a half dozen species belonging to the pleurocerid group, of which *canaliculatum* is a type, might be separated from the material before me. Many thousands of this shell have been taken at the Falls of the Ohio

opposite Louisville. They present a still wider range of variation, perhaps from the character of their habitat. The very wide range of variation suggests some interesting synonymic conclusions that it is hoped will be elaborated during the coming year.

Goniobasis pulchella Anthony.

Wabash River, Ohio River at the Falls, Turkey Creek.

Widely distributed over the State, and with *Goniobasis livescens* Menke, ranges farthest north.

Goniobasis livescens Menke.

Turkey Creek, St. Joseph River.

Goniobasis sp.

A very great quantity of these small shells were collected by me at the Falls of the Ohio during the past three years, but opportunity to work it up has not yet been afforded. As in the pleuroceroid section, this material promises an abundant synonymy.

Lioplax subcarinata Say.

Wabash River, Ohio River.

Vivipara intertexta Say.

Wabash River, Gibson County, Lake Maxinkuckee.

Vivipara contectoides Binney.

Lake Maxinkuckee, ponds along Wabash River.

Campeloma decisum Say.

St. Joseph River, Lake Maxinkuckee.

Campeloma ponderosum Say.

Ohio River, Wabash River, ponds in Vigo County.

Campeloma rufum Haldeman.

St. Joseph River.

Campeloma subsolidum Anthony.

Peru, Lake Maxinkuckee, White River.

The very interesting and very difficult group of shells comprised in *Campeloma* is probably the least understood and the most abused of any in the North American fauna. At brief intervals some tyro arises to declare his "discovery that after all there is but one species," etc., etc., the latest of these being a writer in the "Proceedings of the Iowa Academy of Sciences."* In this paper the remarkable suggestion is confidently made that "Mr. Binney's disposition of these forms is still the best." Now, Mr. Binney wrote on these mollusks thirty

* Proc. Iowa Acad. of Sciences, 1893 [1894], p. 108. Shimek, "Additional Notes on Iowa Mollusca."

years ago, with poor and scanty materials at his command. He succeeded in involving the group in almost inextricable confusion for nearly a quarter of a century, a result hardly to be wondered at with paucity of material and want of familiarity with fresh water forms. So far from the truth is it that Mr. Binney's disposition of these forms was wise that, without detracting a whit from his well earned reputation as a student of our terrestrial mollusca, it may be fairly stated that had he left the group severely alone its limitations would sooner and better be reached. As species go, every form listed from Indiana is distinct and is easily separable, no matter how mixed the material may be. The embryonic forms differ; the mature shells differ; their character is obvious to any who will carefully study extensive series. What the specific value of certain forms may eventually prove to be does not in the least affect the general proposition that the group is composed of a number of forms which must be recognized as species. It would, indeed, be a striking commentary on the acumen of American conchologists if, after thirty years, no advance had been made in this group. And this same writer accepts several undoubted synonyms of the circumpolar *Vallonia pulchella* Müller, as good species!

CORBICULADÆ.

Sphærium sulcatum Lamarck.

Ponds, Vigo County.

Sphærium striatinum Lamarck.

Turkey Creek; Ohio River; Ponds, Vigo County.

Sphærium transversum Say.

Abundant in the Ohio at Charleston.

UNIONIDÆ.

**Anodonta edentula* Say.

Ponds, Vigo County; Bennett's Creek; Wabash River; Cedar Creek; St. Joseph River.

**Anodonta ferussaciana* Lea.

Bennett's and Coal creeks, Vigo County; Five Mile Pond, Vigo County; St. Joseph River.

Anodonta footiana Lea.

Lake Hamilton; Lake Maxinkuckee.

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* All names thus marked have Indiana representatives in the State Museum, at Indianapolis.

**Anodonta grandis* Say.

Fourteen Mile Creek, Charleston; Lake Hamilton; Five Mile Pond, Vigo County; Raccoon Creek.

Anodonta imbecillis Say.

Bennett's Creek, Vigo County.

Anodonta pavonia Lea.

Pond, near Terre Haute; Bennett's and Coal creeks, Vigo County.

Anodonta salmonia Lea.

Yellow River; Cedar Creek; St. Joseph River.

**Anodonta suborbiculata* Say.

Wabash River.

**Anodonta subcylindracea* Lea.

Wabash River; Cedar Creek.

Anodonta undulata Say.

Lake Maxinkuckee.

Anodonta wardiana Lea.

Fourteen Mile Creek, Charleston.

**Margaritana calceola* Lea.

Wabash River, White River, Turkey Lake.

**Margaritana complanata* Barnes.

Wabash River, White River, Ohio River, Bruiett's Creek.

**Margaritana confragosa* Say.

Wabash River.

**Margaritana dehiscens* Say.

Wabash River, Ohio River.

**Margaritana deltoidea* Lea.

Lake Maxinkuckee, St. Joseph River.

This form is a synonym of *Margaritana calceola* Lea.

**Margaritana hildrethiana* Lea.

Wabash River.

**Margaritana marginata* Say.

Wabash River, White River, Ohio River, St. Mary's River.

**Margaritana monodonta* Say.

Ohio River, Wabash River.

This shell was described, in 1830, from the Falls of the Ohio, by Mr. Say, but was by him regarded as a *Unio*. Mr. Lea described it the same year as *Unio soleniformis*. Mr. Lea's shell is given the indefinite locality "Ohio," and the shell probably came from the Ohio River, near Cincinnati. Mr. Say's name has

priority, even though it is now recognized that the species falls in *Margaritana* rather than in *Unio*.

In habit the species resembles *Margaritana dehiscens* in that it is often deeply buried in the gravelly banks it affects, in rather swiftly flowing water. Most commonly, however, it may be found buried deeply under large flat rocks, and between clefts in rocky bottoms. It is a rather rare shell in collections.

* *Margaritana rugosa* Barnes.

Wabash River, White River, Blue River, Fourteen Mile Creek.

* *Unio æsopus* Green.

Wabash River, Ohio River.

* *Unio alatus* Say.

White River, Ohio River, Wabash River.

* *Unio anodontoides* Lea.

Wabash River, Ohio River, Bruisett's Creek, Vigo County.

* *Unio asperrimus* Lea.

Wabash River, Ohio River, at the Falls; this form is equivalent to *Unio lachrymosus* Lea.

* *Unio camelus* Lea.

Ohio River; this is an old and heavy *Unio phaseolus*, of which it is a synomym,

* *Unio camptodon* Say.

Wabash River, Ohio River.

* *Unio capax* Green.

Wabash River, Ohio River.

* *Unio cicatricosus* Say.

Wabash River, Ohio River.

* *Unio circulus* Lea.

St. Mary's River, Ohio River, Wabash River, Peru.

* *Unio clavus* Lamarck.

Wabash River, very abundant; St. Joseph River.

* *Unio coccineus* Hildreth.

Wabash River, Ohio River.

* *Unio cooperianus* Lea.

Wabash River, Ohio River.

* *Unio cornutus* Barnes.

Ohio River, Wabash River.

* *Unio crassidens* Lamarck.

Wabash River, Falls of the Ohio, abundant.

* *Unio cylindricus* Say.

Ohio River, Wabash River, White River.

These shells, as are indeed most others from the Wabash River, are singularly beautiful and perfect. Even the largest and oldest examples present perfect umbones, with epidermis and apical crenulations entire. It is rare indeed to find these forms so perfect. Both this species and *Unio metanervus*, which are characterized by peculiar arrow-shaped green color-markings over the whole disk, present this feature in singular beauty. The State Collection, at Indianapolis, contains several well-marked and beautiful specimens.

* *Unio donaciformis* Lea.

Wabash River, Ohio River at Falls of the Ohio; found, also, in collections under the name of *Unio zigzag* Lea. The latter name was given two years after *Unio donaciformis* was characterized.

* *Unio ebenus* Lea.

Wabash River, Ohio River, Falls of the Ohio.

* *Unio elegans* Lea.

Wabash River. Ohio River, Falls of the Ohio.

* *Unio ellipsis* Lea.

Wabash River, Ohio River, Falls of the Ohio, common.

* *Unio fabalis* Lea.

Wabash River.

Unio lapillus Say, is a synonym of this form.

* *Unio fragosus*, Conrad.

Wabash River, Ohio River, White River.

* *Unio gibbosus* Barnes.

Wabash River, Sand Creek, Ohio River, Turkey Lake, Lake Tippecanoe, St. Joseph River, Lake Maxinkuckee, Falls of the Ohio, St. Mary's River.

The white and heavy variety of this shell, called by Dr. Lea, *Unio arctior*, occurs somewhat commonly in both the Ohio and Wabash rivers.

* *Unio glans* Lea.

Wabash River, White River, Lake Maxinkuckee.

* *Unio gracilis* Barnes.

Wabash River, Ohio River on Falls of the Ohio, Muscatatuck Creek, Jennings County.

* *Unio graniferus* Lea.

Wabash River, Ohio River.

* *Unio iris* Lea.

Wabash River, Delaware River, Lake Maxinkuckee.

* *Unio irrorratus* Lea.

Wabash River, Ohio River. Very abundant, perfect and beautiful in the Wabash.

* *Unio lens* Lea.

See *Unio circulus*, of which it is a synonym.

* *Unio ligamentinus* Lamarck.

Wabash River, Ohio River, Yellow River, Turkey Creek, Delaware River, St. Joseph River. Widely distributed over the State. The most common *Unio* of our waters, with the possible exception of *Unio luteolus*.

* *Unio luteolus* Lamarck.

Whitewater River, White River, Wabash River, Ohio River, St. Mary's River, Turkey Creek, Cedar Creek, Fourteen Mile Creek, Charleston; Lake Maxinkuckee.

* *Unio metanevrus* Rafinesque.

Wabash River, Ohio River.

* *Unio multiplicatus* Lea.

Wabash River, Ohio River; a mud-loving form which reaches gigantic size in both these streams. Very large and fine specimens are in the State collection.

* *Unio multiradiatus* Lea.

Wabash River, White River, St. Joseph River.

* *Unio mytiloides* Rafinesque.

Wabash River, Ohio River.

* *Unio nigerrimus* Lea.

Wabash River; a single specimen is in the State collection, labelled correctly as above—though the locality can not be vouched for. Mr. Lea described the form from Alexandria, Louisiana. The collection contains many southern shells and I am inclined to regard this locality reference as an error and to think the shell should not be reckoned as an Indiana form.

* *Unic obliquus* Lamarck.

Wabash River, Ohio River; probably the same form Rafinesque called *mytiloides*.

* *Unio occidens* Lea.

Decatur County, Ohio River, Wabash River, Falls of the Ohio, Bennett's Creek, Vigo County.

* *Unio orbiculatus* Hildreth.

Wabash River; Mr. Lea later described the female of this species under the name of *Unio higginsii*.

* *Unio parvus* Barnes.

Wabash River, Ohio River, Creek at Greencastle (Underwood), Lake Maxinkuckee.

Very large specimens of this usually small shell are obtained in the Wabash. So marked is their development that they are commonly known as "the big *parvus* of the Wabash."

* *Unio perplexus* Lea.

Wabash River, White River.

Mr. Lea later twice described again this form, once as *Unio rangianus* and then as *Unio sampsonii*, both the latter from Indiana waters. It has other synonyms, by the same writer, in Tennessee waters.

* *Unio phaseolus* Barnes.

Wabash River, Ohio River, St. Joseph River, Lake Maxinkuckee, Fourteen Mile Creek, near Charleston.

* *Unio plenus* Lea.

Wabash River.

* *Unio plicatus* Le Sueur.

Ohio River, Wabash River.

This shell, widely distributed, has a number of synonyms which I have elsewhere indicated.† It is also often confounded with *Unio undulatus* Barnes, which is, however, a markedly different shell, very much more compressed.

* *Unio pressus* Lea.

Sand Creek, Decatur County; Bruiett's Creek, Vigo County; St. Joseph River, Lake Maxinkuckee.

* *Unio pustulatus* Lea.

Ohio River, Wabash River, White River.

* *Unio pustulosus* Lea.

Wabash River, Ohio River.

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† See Trans. St. Louis Acad. Sci., Vol. VII, No. 1, pp. 36, 37; 1896.

* *Unio rectus* Lamarck.

Wabash River, Ohio River, White River, St. Joseph River.

* *Unio retusus* Lamarck.

Wabash River.

* *Unio ridibundus* Say.

White River, Wabash River.

* *Unio rubiginosus* Lea.

Ohio River, Wabash River, Lake Maxinkuckee.

* *Unio securis* Lea.

Wabash River, Ohio River.

* *Unio solidus* Lea.

Wabash River.

* *Unio subovatus* Say.

Wabash River, Ohio River, White River.

* *Unio subrostratus* Say.

Wabash River, Lake Maxinkuckee, Bruiett's Creek, Vigo County.

Wrongly labelled *Unio nasutus* in the State collection.

* *Unio sulcatus* Lea.

White River, Marion County.

* *Unio tenuissimus* Lea.

Wabash River, Ohio River.

A specimen in the State collection is labelled *Unio vellum* Say.

* *Unio triangularis* Barnes.

Wabash River, White River.

* *Unio trigonus* Lea.

Wabash River, Ohio River.

* *Unio tuberculatus* Barnes.

Ohio River, Falls of the Ohio, Wabash River.

* *Unio undulatus* Barnes.

White River, Ohio River, Wabash River, Bruiett's Creek, Vigo County.

* *Unio varicosus* Lea.

Ohio River.

* *Unio ventricosus* Barnes.

Lake Maxinkuckee, St. Joseph River.

* *Unio verrucosus* Barnes.

Wabash River, Ohio River, White River.

CINCINNATI, OHIO, December 23, 1895.

Contributions to the Biological Survey of Wabash County. By Albert B. Ulrey.

The present paper is intended (1) to indicate the progress made during the year in listing the fauna and flora of Wabash County, and (2) to give a summarized statement of the work already done, thus placing the material collected within access of those interested in special lines.

I have included in these lists, with but a few exceptions, only those forms of which specimens were preserved:

I. The Fauna:

1. The list of fishes includes forty-two species, seven of which were not noted in the last published report. I have included in the list the Brook Lamprey (*Ammocœtes branchialis*). Several specimens were taken in a creek near North Manchester, about May 15, 1895.
2. Batrachians, 19.
   - *a.* Salamanders and Water Dog (*Urodela and Proteida*), 10.
   - *b.* Tailless Batrachians (*Salientia*), 9.
3. Reptiles, 18.
   - *a.* Snakes (*Ophidia*), 11.
   - *b.* Lizards (*Lacertilia*), 1.
   - *c.* Turtles (*Testudinata*), 6.
4. Birds.

   The list of birds includes 186 species. Two specimens of the Horned Grebe (*Colymbus auritus L.*) were taken along the roadside November 27, 1895, after a severe storm. This is the first record of the bird in the county. Mr. W. O. Wallace has taken another specimen of the rare Kirtland's Warbler (*Dendroica kirtlandi*) at Wabash. It was taken some time in May, 1895.
5. The mammals listed include about twenty species.

II. The Flora:

Among Phanerogams the list comprises about 750 species representing eighty-nine families. Only a few of the forest trees are included, 116 species of grasses and twenty-three sedges. About 400 species have been added during the year.

The Cryptogams have not been listed, but some valuable material has been collected in certain groups, such as the ferns and some forms of fungi.

In the collection of Dr. A. Miller, of North Manchester, Ind., there are probably 175 species of parasitic fungi and perhaps twenty-five species of the Slime Moulds, if I may, for convenience, still place them among the fungi.

Nearly a complete list of the Phanerogams may be found in the herbarium of Mr. John N. Jenkins, North Manchester, Ind., who has done valuable work in collecting these forms.

Birds of Wabash County. By Albert B. Ulrey and William O. Wallace.

The present list enumerates 188 species of the birds of Wabash County. Under each species are given notes concerning its abundance and in some instances we have incorporated other observations which pertain to the life-history of the species.

Most of the work was done at intervals during the years 1890 to 1893. Part of the observations were made in the extreme northern portion of the county in the Eel River valley, near North Manchester. About an equal amount of work was done in the Wabash valley near Wabash, and some observations were made nine miles north of Lagro by Mr. Orrin Ridgley.

We have included in the list only those species identified by us, and with only a few exceptions skins of each species have been preserved. We have noted the breeding habits of those species only which came under our own observation. We may expect to find two hundred or more birds within the county. The list is quite complete in warblers, containing 31 species, one of them the very rare *Dendroica kirtlandi*. Perhaps three more would complete the list to be found in the county. We shall probably find *Protonotaria citrea*, *Helmitherus vermivorous* and *Geothlypis formosa*. The deficiencies in our list are mainly among the water birds. Our only large stream, the Wabash, flows nearly eastward here and is not rich in migrating water birds. The region in the northwestern part of the county, containing numerous small lakes, has not contributed many species to our list, because only a few of the rarer birds taken there by the hunters have been identified by us.

The Wabash River flows in a northerly direction to Logansport, where it bends abruptly to the east and continues in this direction through the county. Near Wabash one of the tributaries of the Wabash River flows nearly due southward. A heavy growth of timber extends along the stream northward some distance from the Wabash and ends abruptly at a large tract of land under cultivation. During the spring migrations the birds collect in the north edge of this

woodland in great numbers. It seems that in their northward migrations along the Wabash River the birds attempt to follow the wooded region of the smaller stream instead of pursuing the eastward course of the Wabash, and on reaching the open fields find themselves in a sort of trap. It was at this place that a large per cent. of the birds inhabiting the woodland were taken.

1. *Podylimbus podiceps* Linnæus. Pied-billed Grebe. Rather common migrant.

2. *Colymbus auritus* L. Horned Grebe. Two specimens were taken November 27, 1895, after a severe storm.

3. *Urinator imber* Gunner. Loon. Great Northern Diver. Not infrequently taken on the lakes. Five or six were taken on the Wabash River near Wabash.

4. *Larus argentatus smithsonianus* Coues. American Herring Gull. One specimen taken as it flew over the house four miles west of Wabash. The specimen was taken by Mr. E. Wright and is now in his possession.

5. *Larus philadelphiæ* Ord. Bonaparte's Gull. One specimen taken on Lake Maxinkuckee. It will probably be taken here.

6. *Sterna forsteri* Nutt. Forster's Tern. Several specimens were taken on Lake Maxinkuckee.

7. *Hydrochelidon nigra surinamensis* Gmel. Black Tern. Probably taken here. We have a specimen from the same place as the last.

8. *Phalacrocorax dilophus* Sw. and Rich. Double-crested Cormorant. A male and female were taken on Long Lake, November 15, 1890.

9. *Merganser americanus* Cassin. American Merganser. Not uncommon migrant and winter resident.

10. *Lophodytes cucullatus* Linnæus. Hooded Marganser. Rare. Three specimens taken.

11. *Anas boschas* Linnæus. Mallard. Abundant migrant; sometimes taken in midwinter, and three were killed July 3, 1892, by Mr. E. Wright. Hunters report its breeding, but we have not observed it.

11*a*. *Anas obscura* Gmelin. Black Duck. One specimen taken at Wabash.

12. *Anas discors* Linnæus. Blue-winged Teal. Only one specimen. It was taken April 15, 1891.

13. *Aix sponsa* Linnæus. Wood Duck. Abundant summer resident. I have taken the young when still unable to fly. Wallace.

13*a*. *Spatula clypeata* L. Spoon Bill. Only one specimen taken. Wabash.

14. *Aythya affinis* Eyt. Lesser Scaup Duck. A specimen was taken on Long Lake, November 15, 1890.

15. *Charitonetta albeola* Linnæus. Butter Ball. One specimen from Long Lake. Occasionally killed on Eel River by hunters.

16. *Branta canadensis* Linnæus. Canada Goose. One specimen taken; frequently seen migrating.

17. *Olor columbianus* Ord. Whistling Swan. One specimen taken November 15, 1894, on Long Lake.

18. *Botaurus lentiginosus* Montag. American Bittern. Several specimens known to have been taken.

19. *Botaurus exilis* Gmelin. Least Bittern. Two specimens taken, April 19 and May 1, 1894.

20. *Ardea herodias* Linnæus. Great Blue Heron. Common summer resident.

21. *Ardea egretta* Linnæus. American Egret. A specimen taken just beyond the north line of Wabash County, in Kosciusko County.

22. *Ardea virescens* Linnæus. Green Heron. Abundant summer resident. Breeds.

23. *Nycticorax nycticorax nævius* Bodd. Black-crowned Night Heron. Two specimens taken. One at North Manchester and one at Wabash.

24. *Rallus virginianus* Linnæus. Virginia Rail. One specimen taken at Rock Lake, in Fulton County just across the line, September 1, 1894.

25. *Porzana carolina* Linnæus. Carolina Rail. Not infrequently taken by hunters.

26. *Fulica americana* Gmel. American Coot. Abundant migrant.

27. *Philohela minor* Gmel. American Woodcock. Not very common.

28. *Gallinago delicata* Ord. Wilson's Snipe. I took a specimen January 1, 1892, and the same winter two were killed between December 25th and January 1 by a friend of mine. I have seen them in midsummer. Wallace.

29. *Tringa maculata* Vieillot. Jack Snipe. Very common during migrations, especially in September. It may be found at this time in great abundance along the Wabash River in company with the Solitary Tattler and Killdeer.

30. *Tringa minutilla* Vieillot. Least Sandpiper. Rare. One specimen taken from a flock of Solitary Tattlers, August 29, 1893.

31. *Tringa bairdii* Coues. Baird's Sandpiper. Rare. Only one specimen taken. This is apparently the only record of the bird in the State. [Proc. Ind. Acad. Sci. 1893, p. 118].

32. *Totanus melanoleucus* Gmelin. Greater Yellow-legs. I have never seen this bird except on September 24 and 25, 1893, when I observed a number along the river, three of which I shot. Wallace.

33. *Totanus solitarius* Wilson. Solitary Tattler. Very common summer resident. Breeds.

34. *Bartramia longicauda* Bechst. Upland Plover. One specimen taken from a flock of three.

35. *Actitis macularia* Linnæus. Spotted Sandpiper. Very common summer resident. Breeds.

36. *Ægialites vocifera* Linnæus. Killdeer. Abundant summer resident. Breeds.

37. *Colinus virginianus* Linnæus. Bob-white. Formerly very abundant, but much less so since the winter of 1892-3, when they were destroyed in great numbers by the severe cold and snow.

38. *Bonasa umbellus* Linnæus. Pheasant. Formerly common, now becoming rare.

39. *Tympanuchus americanus* Reich. Prairie Hen. Occasionally taken on the prairie region near Wabash.

40. *Meleagris gallopavo* Linnæus. Wild Turkey. Formerly common, now probably extinct. The last one known to have been taken was in 1880.

41. *Ectopistes migratorius* Linnæus. Wild Pigeon. Formerly abundant, but none have been seen recently.

42. *Zenaidura macroura* Linnæus. Turtle Dove. Very common resident. Breeds.

43. *Cathartes aura* Linnæus. Turkey Buzzard. Abundant summer resident. Breeds in hollow logs, trees, etc.

44. *Circus hudsonius* Linnæus. Marsh Hawk. Rather common about prairie regions. Extremely variable in color. Breeds.

45. *Accipiter cooperi* Bonaparte. Cooper's Hawk. Common. Probably our most common injurious hawk.

46. *Buteo borealis* Gmelin. Red-tailed Hawk. Abundant resident. Breeds.

47. *Buteo lineatus* Gmelin. Red-shouldered Hawk. One specimen taken.

48. *Buteo latissimus* Wilson. Broad-winged Hawk. Two specimens taken.

49. *Falco sparverius* Linnæus. American Sparrow Hawk. Quite abundant resident. Breeds.

50. *Strix pratincola* Bonaparte. American Barn Owl. A single specimen taken by Mr. Frank Bell at North Manchester.

51. *Asio wilsonianus* Less. American Long-eared Owl. A specimen was taken near the north county line. It is in the collection of Mr. M. L. Galbreath.

52. *Asio accipitrinis* Pallas. Short-eared Owl. Four specimens taken at Wabash and one just north of the county line in Whitley County.

53. *Syrnium nebulosum* Forst. Barred Owl. Quite abundant resident.

54. *Nyctala acadica* Gmelin. Saw-whet Owl. One specimen taken November 20, 1894.

55. *Megascops asio* Linnæus. Screech Owl. Abundant, both red and gray phases.

56. *Bubo virginianus* Gmelin. Great Horned Owl. Abundant resident. Breeds.

57. *Nyctea nyctea* Linnæus. Snowy Owl. A specimen of this owl was taken near Roann, probably during the winter of 1891-2, another near North Manchester during the winter of 1893 and one in 1894.

58. *Coccyzus americanus* Linnæus. Yellow-billed Cuckoo. Abundant summer resident. Breeds.

59. *Coccyzus erythrophthalmus* Wilson. Black-billed Cuckoo. One or two specimens taken. Perhaps rather common.

60. *Ceryle alcyon* Linnæus. Belted Kingfisher. Abundant summer resident. Breeds.

61. *Dryobates villosus* Linnæus. Hairy Woodpecker. Abundant resident.

62. *Dryobates pubescens* Linnæus. Downy Woodpecker. Abundant resident. Breeds.

63. *Sphyrapicus varius* Linnæus. Yellow-bellied Woodpecker. Common migrant.

64. *Ceophlœus pileatus* Linnæus. Pileated Woodpecker. Formerly common, but none have been seen recently.

65. *Melanerpes erythrocephalus* Linnæus. Red-headed Woodpecker. Abundant, some years resident. Breeds.

66. *Melanerpes carolinus* Linnæus. Red-bellied Woodpecker. Abundant resident, more common in winter.

67. *Colaptes auratus* Linnæus. Flicker. Abundant resident. Breeds.

68. *Antrostomus vociferus* Wilson. Whip-poor-will. Abundant summer resident.

69. *Chordeiles virginianus* Gmelin. Night Hawk. Common summer resident, more common in late summer.

70. *Chætura pelagica* Linnæus. Chimney Swift. Abundant summer resident. Breeds.

71. *Trochilus colubris* Linnæus. Ruby-throated Humming-bird. Common summer resident. Breeds. On May 19, 1894, two were found dead after a few days cold weather.

72. *Tyrannus tyrannus* Linnæus. Kingbird. Very common summer resident. Breeds.

73. *Myiarchus crinitus* Linnæus. Crested Fly-catcher. Common summer resident. Breeds.

74. *Sayornis phœbe* Latham. Phœbe. Abundant summer resident. Breeds.

75. *Contopus virens* Linnæus. Wood Pewee. Very common summer resident. Breeds.

76. *Empidonax flaviventris* Baird. Yellow-bellied Fly-catcher. Not very common migrant.

77. *Empidonax acadicus* Gmelin. Acadian Fly-catcher. A common migrant.

78. *Empidonax minimus* Baird. Least Fly-catcher. Not very common migrant.

79. *Otocorys alpestris praticola* Hensh. Prairie Horned Lark. Resident. Breeds. More abundant during severe cold in winter.

80. *Cyanocitta cristata* Linnæus. Blue Jay. Abundant resident. Very destructive to young birds and eggs.

81. *Corvus americanus* Aud. American Crow. Abundant resident. Breeds.

82. *Dolichonyx oryzivorus* Linnæus. Bob-o-link. Summer resident. Breeds. Formerly rare or wanting. Becoming more common every summer.

83. *Molothrus ater* Bodd. Cow bird. Abundant summer resident.

84. *Agelaius phœniceus* Linnæus. Red-winged Blackbird. Abundant summer resident breeding in swamps.

85. *Sturnella magna* Linnæus. Meadow Lark. Common summer resident and often seen in mid-winter. Breeds.

86. *Icterus spurius* Linnæus. Orchard Oriole. Common summer resident. Breeds.

87. *Icterus galbula* Linnæus. Baltimore Oriole. Probably more abundant than the last species. Breeds.

88. *Scolecophagus carolinus* Müll. Rusty Blackbird. Rather common migrant.

89. *Quiscalus quiscula æneus* Ridgway. Crow Blackbird. Abundant summer resident, sometimes seen in mid-winter.

90. *Coccothraustes vespertina* Coop. Evening Grosbeak. Two pair were taken just beyond the north county line in Whitley County, one pair of which is in the collection of Mr. M. L. Galbreath, Collamer, Ind.

91. *Carpodacus purpureus* Gmel. Purple Finch. Migrant, not very common.

92. *Loxia curvirostra minor* Brehm. American Crossbill. Two specimens seen September 11, 1894, in the cemetery at Wabash.

93. *Acanthus linaria* Linnæus. Redpoll Linnet. Several flocks were seen during the winter of 1889–90. This is the only time they have been noted in the county except a record of the same date by Mr. D. C. Ridgley, nine miles north of Lagro.

94. *Spinis tristis* Linnæus. American Goldfinch. Abundant resident. Breeds.

95. *Spinus pinus* Wils. Pine Siskin. One shot from a flock of goldfinches which came to feed on the mulleins in our yard January 10, 1892. (Wallace.)

96. *Calcarius lapponicus* Linnæus. Lapland Longspur. This bird was first taken by Mr. Orrin Ridgley in the fall of 1891. At Wabash one was taken in 1892, and during the winter of 1893–94 they were common, coming in September and remaining until March 15. All were in company with Horned Larks.

97. *Poocætes gramineus* Gmel. Bay-winged Bunting. Very abundant summer resident.

98. *Passer domestica* Linnæus. European House Sparrow. "English Sparrow." Very abundant resident. Not so abundant as in 1892. A great many were destroyed during the winter of 1892–93.

99. *Ammodramus sandwichensis savanna* Wils. Savanna Sparrow. Migrant, not common.

100. *Ammodramus savannarum passerinus* Wils. Grasshopper Sparrow. Abundant summer resident. Breeds.

101. *Chondestes grammacus* Say. Lark Sparrow. Not very common summer resident. Breeds. More common during migrations.

102. *Zonotrichia leucophrys* Forst. White-crowned Sparrow. Abundant migrant, occasionally seen as late as June 10.

103. *Zonotrichia albicollis* Gmel. White-throated Sparrow. Much more abundant than the last species. Its peculiar note, once heard, is not readily forgotten.

104. *Spizella monticola* Gmel. Tree Sparrow. Abundant winter resident.

105. *Spizella socialis* Wils. Chipping Sparrow. Very common summer resident. Breeds.

106. *Spizella pusilla* Wils. Field Sparrow. Abundant summer resident. Breeds.

107. *Junco hyemalis* Linnæus. Slate-colored Junco. Snowbird. Common winter resident, but more abundant in fall and spring.

108. *Melospiza fasciata* Gmel.. Song Sparrow. Abundant resident. Breeds.

109. *Melospiza georgiana* Lath. Swamp Sparrow. Migrant, not common.

110. *Passerella iliaca* Merr. Fox Sparrow. Common early migrant.

111. *Pipilo erythrophthalmus* Linnæus. Towhee. Chewink. Common summer resident. Breeds. A few remain over winter.

112. *Cardinalis cardinalis* Linnæus. Cardinal Grosbeak. A common resident, less so than formerly. Breeds.

113. *Habia ludvoiciana* Linnæus. Rose-breasted Grosbeak. Summer resident, sometimes abundant and sometimes wanting. Breeds.

114. *Passerina cyanea* Linnæus. Indigo Bunting. Very common summer resident. Breeds.

115. *Spiza americana* Gmel. Black-throated Bunting. Very abundant summer resident. Breeds.

116. *Piranga erythromelas* Vieill. Scarlet Tanager. Common summer resident. Breeds.

117. *Progne subis* Linnæus. Purple Martin. Summer resident, abundant in cities. Breeds.

118. *Petrochelidon lunifrons* Say. Cliff Swallow. Summer resident, breeds, but is not so common as formerly. It has been driven out by the English Sparrow.

119. *Chelidon erythrogaster* Bodd. Barn Swallow. Adundant summer resident. Breeds.

120. *Tachycineta bicolor* Vieillot. Tree Swallow. Not often seen. They were observed in some abundance in the fall of '93.

121. *Clivicola riparia* Linnæus. Bank Swallow. Common along the Wabash River. Breeds.

122. *Stelgidopteryx serripennis* Aud. Rough-winged Swallow. Only two specimens taken.

123. *Ampelis garrulus* Linnæus. Bohemian Waxwing. A specimen was taken near the Wabash County line and is now in the collection of Mr. M. L Galbreath.

124. *Ampelis cedrorum* Vieill.. Cedar Bird. Common resident. Breeds late in summer.

125. *Lanius borealis* Vieill. Northern Shrike. Butcher Bird. Winter resident, not abundant.

126. *Lanius ludovicianus excubitorides* Swainson. White-rumped Shrike. Common summer resident. Breeds. The typical species may also be found here.

127. *Vireo olivaceous* Linnæus. Red-eyed Vireo. Abundant summer resident. Breeds.

128. *Vireo philadelphicus* Cassin. Philadelphia Vireo. Rather rare migrant.

129. *Vireo gilvus* Vieill. Warbling Vireo. Common summer resident. Breeds.

130. *Vireo flavifrons* Vieill. Yellow-throated Vireo. Abundant migrant.

131. *Vireo solitarius* Wils. Blue-headed Vireo. Migrant; not common.

132. *Mniotilta varia* Linnæus. Black and White Warbler. Abundant in woodland during migrations.

133. *Helminthophila pinus* Linnæus. Blue-winged Warbler. Summer resident, never very common. Breeds.

134. *Helminthophila chrysoptera* Linnæus. Golden-winged Warbler. Migrant; not so common as the last.

135. *Helminthophila ruficapilla* Wils. Nashville Warbler. An abundant migrant.

136. *Helminthophila celeta* Say. Orange-crowned Warbler. Rare. One specimen taken May 15, 1892.

137. *Helminthophila perigrina* Wils. Tennessee Warbler. Abundant migrant; most common in fall, when they may be found in great abundance along the rivers.

138. *Compsothlypis americana* Linnæus. Parula Warbler. A rare migrant; two specimens taken.

139. *Dendroica tigrina* Gmel. Cape May Warbler. Migrant; not common.

140. *Dendroica æstiva* Gmel. Yellow Warbler. Very common summer resident. Breeds.

141. *Dendroica cærulescens* Gmel. Black-throated Blue Warbler. Migrant; common. In the fall of 1893 it was probably our commonest warbler. It is fond of the dense woodland.

142. *Dendroica coronata* Linnæus. Yellow-rumped Warbler. The earliest of the warblers to arrive and the last to go in the fall. It is probably our most abundant warbler.

143. *Dendroica maculosa* Gmel. Magnolia Warbler. Not very common. Its habits of seclusion make it seem less common than others of equal abundance.

144. *Dendroica cærulea* Wils. Cærulean Warbler. Rather common. So far it has been found only during the migrating season.

145. *Dendroica pennsylvanica* Linnæus. Chestnut-sided Warbler. Common migrant.

146. *Dendroica castanea* Wils. Bay-breasted Warbler. Not common; most most frequently seen in the fall.

147. *Dendroica striata* Forst. Black-poll Warbler. Rather rare migrant.

148. *Dendroica blackburniæ* Gmel. Blackburnian Warbler. Abundant migrant.

149. *Dendroica dominica albilora* Baird. Sycamore Warbler. Rather rare migrant.

150. *Dendroica virens.* Gmel. Black-throated Green Warbler. Very abundant migrant.

151. *Dendroica vigorsii* Aud. Pine-creeping Warbler. Only two specimens taken in the county.

152. *Dendroica kirtlandi* Baird. Kirtland's Warbler. The only specimen known in the State was taken May 4, 1892. This is the twenty-second specimen reported from North America. Little is known of its life history. I took it in a thicket. It was alone, there being no other birds in the near vicinity of it. It seemed to be an active fly catcher, not having the motions of the other *Dendroicæ*, being less active. It would dart off after an insect and then return to the same perch. Another specimen was taken May 7, 1895. Early in the morning I heard a bird singing in the thicket of plum trees near the house. The song was strange to me, and consisted of a loud ringing note repeated three times in quick succession, suggesting that of the Wrens or Maryland Yellow Throat. I did not go to look for it at once, but as it continued singing for some time I finally got my gun and went to look for it. It had flown over into the orchard then, but soon returned to the plum thicket and was constantly uttering that peculiar note. I finally caught sight of it and watched it for some time, not thinking of its being the rare *kirtandi*. It moved with the grace and ease of a vireo or fly-catcher. Wallace. [Proc. Ind. Academy of Science, 1893, pp. 119, 120].

153. *Dendroica discolor* Vieill. Prairie Warbler. One specimen was taken May 2, 1892.

154. *Dendroica palmarum* Gmel. Red poll Warbler. Abundant migrant.

155. *Seiurus aurocapillis* Linnæus. Oven-bird. Very common summer resident.

156. *Seiurus noveboracensis* Gmel. Short-billed Water Thrush. Rather rare migrant.

157. *Seiurus motacilla* Vieill. Large-billed Water Thrush. Summer resident; more common than the last. Arrives as early as April 3.

158. *Geothlypis agilis* Wils. Connecticut Warbler. Only one specimen taken.

159. *Geothlypis philadelphia* Wils. Mourning Warbler. Found in dense thickets. It was rather common in the spring of 1892, but has not been seen since.

160. *Geothlypis trichas* Linnæus. Maryland Yellow-throat. Abundant summer resident.

161. *Icteria virens* Linn. Yellow-breasted Chat. Summer resident, not common.

162. *Sylvania mitrata* Gmel. Hooded Warbler. One specimen was taken September 13, 1893.

163. *Sylvania pusilla* Wils. Black-capped Yellow Warbler. Three specimens were seen during the spring of 1892, but it has not been noted since.

164. *Sylvania canidensis* Linnæus. ' Canadian Fly-catching Warbler. A common migrant.

165. *Setophiga ruticilla* Linnæus. American Redstart. Summer resident, but much more common during migrations.

166. *Anthus pennsylvanicus* Lath. American Titlark. A migrant of irregular occurrence, but in some seasons very abundant.

167. *Galeoscoptes carolinensis* Linnæus. Cat-bird. Abundant summer resident. Breeds.

168. *Harporhynchus rufus* Linnæus. Brown Thrusher, Brown Thrush. Abundant summer resident.

169. *Thryothorus ludovicianus* Lath. Carolina Wren. Rather rare resident. Some seasons none are seen.

170. *Thryothurus bewickii* Aud. Bewick's Wren. Rather common summer resident.

171. *Troglodytes aedon* Vieill. House Wren. Common summer resident. Breeds.

172. *Troglodytes hyemalis* Vieill. Winter Wren. Common migrant. Probably some remain throughout the winter.

173. *Certhia familiaris americana* Bonap. Brown Creeper. Common migrant. Occasionally seen in midwinter.

174. *Sitta carolinensis* Lath. White-breasted Nuthatch. Common resident.

175. *Sitta canadensis* Linnæus. Red-breasted Nuthatch. One specimen taken Sept. 15th, 1891.

176. *Parus bicolor* Linnæus. Tufted Titmouse. Very common resident.

177. *Parus atrocapillis* Linnæus. Black-capped Chickadee. Abundant winter resident.

178. *Regulus satrapa* Licht. Golden-crowned Kinglet. Common winter resident.

179. *Regulus calendula* Linnæus. Ruby-crowned Kinglet. Common migrant.

180. *Polioptila cærulea* Linnæus. Blue-gray Gnatcatcher. Common summer resident.

181. *Turdus mustelinus* Gmel. Wood Thrush. Common summer resident.

182. *Turdus fuscescens* Steph. Wilson's Thrush. Migrant. Not so common as the preceding.

183. *Turdus ustulatus swainsonii* Cab. Olive-backed Thrush. Rather common migrant.

184. *Turdus aonalaschkæ pallasii* Cab. Hermit Thrush. Common migrant. Our most abundant Thrush.

185. *Merula migratoria* Linnæus. American Robin. Very abundant summer resident. Breeds.

186. *Sialia sialis* Linnæus. Blue Bird. Abundant summer resident. Breeds.

Notes on a Collection of Fishes of Dubois County, Indiana. W. J. Moenkhaus.

The following list of fishes is offered as a slight addition to our knowledge of the fishes of Indiana. The list is based on a collection made during the second week in September, 1893, in Patoka River and Short Creek near Huntingburg, Dubois County, Indiana. It has been withheld from publication thus long because I have hoped that further work might be done in the same streams, but as each year makes this more improbable, it is perhaps best to publish the list as it is. Very little is known of the fishes of the Patoka River, investigations having been made only near its mouth, at the city of Patoka, by Jordan and Evermann, some years ago. (Jordan, Bull. U. S. Fish Com. VIII, 1890).

The Patoka River flows from east to west across about one-half the width of the State. In its course it passes through the southern part of Orange County and through the middle of Dubois, Pike and Gibson counties, emptying into the Wabash a few miles south of the mouth of the White River. In the vicinity of Huntingburg where it was fished, the channel is from 75 to 100 yards in width. The stream is everywhere obstructed along the banks and ofttimes entirely across

by fallen timbers. The water is always more or less muddy, except in the fall, when very low, it approaches clearness. The river was fished for three-quarters of a mile where Hunley Creek empties into it. The water was very low and the fish were mostly collected in the deeper places in the channel. The ripples were repeatedly seined, but were found to be poor in fish. These places seemed ideal for darters, but not a single one was taken here. All that were caught were living together and had collected in the apparently stagnant holes.

Short Creek is a narrow muddy stream about seven miles in length, emptying into Hunley Creek three miles above its mouth. During dry seasons it dries up at many places and presents only pools of yellow, muddy, stagnant water. It was in some of these pools from its mouth to about a mile above that our fishing was done.

Patoka River will be indicated by (*P*) in the descriptions, and Short Creek by (*S*).

All of this collection is in the Indiana University Museum.

The common names given are those by which they are known in this locality:

1. *Ictalurus punctatus* Rafinesque. Channel cat. (P.) Two specimens.
2. *Amiurus melas* Rafinesque. Black cat. (P.) One specimen.
3. *Leptops olivaris* Rafinesque. Flat-head. Mud cat. (P.) One specimen.
4. *Schilbeodes miurus* Jordan. (P.) Sixteen specimens.
5. *Moxostoma aureolum* Le Sueur. Red horse. White sucker. Four specimens from Short Creek and fourteen from the Patoka River.
6. *Hybognathus nuchalis* Agassiz. Thirty-seven specimens from Short Creek and fifty-nine from Patoka River.
7. *Pimephales notatus* Rafinesque. (P.) Seven specimens.
8. *Cliola vigilax* Baird & Girard. (P.) Many specimens.
9. *Notropis microstomus* Rafinesque. (P.) Nineteen specimens.
10. *Notropis whipplei* Girard. (P.) Sixty specimens.
11. *Notropis arcens* Cope. (P.) Twenty specimens.
12. *Notropis umbratilis* Girard. (S.) Fifty-eight specimens.
13. *Notropis atherinoides* Rafinesque. (P.) Thirty-eight specimens.
14. *Opsopoeodus emiliae* Hay. (S.) Two specimens.
15. *Notemigonus chrysoleucus* Mitchell. Golden shiner. (S.) Five specimens.
16. *Dorosoma cepedianum* Le Sueur. Mud shad. Hickory shad. (P.) One specimen.
17. *Zygonectes notatus* Rafinesque. Top minnow. (P. S.) Sixty-one specimens from Patoka River and five from Short Creek.
18. *Lucius vermiculatus* Le Sueur. Pike. Pickerel. (P.) Four specimens.

19. *Labidesthes sicculus* Cope. Silver side. (P.) Five specimens.

20. *Aphredoderus sayanus* Gilliams. (S.) Five specimens.

21. *Pomoxis annularis* Rafinesque. Calico bass. (S.) Twenty specimens. All ages. Six specimens show the following characters: Length, 85, 98, 108, 123, 124, 145; lat. l., 43, 44, 43, 46, 45, 47; dorsal fin, V-15, VI-15, VI-15, VI-14, VI-15, VI-14; anal fin, VI-19, VI-19, VI-18, VI-17, VI-19, VI-17.

22. *Chaenobryttus gulosus* Cuv. & Val. (S.) Four specimens.

23. *Micropterus salmoides* Lacépède. Large-mouthed black bass. (P.) Thirteen specimens. All ages.

24. *Lepomis megalotis* Rafinesque. (S.) One specimen.

25. *Lepomis pallidus* Mitchell. (P. S.) Six specimens from Short Creek and fifteen from Patoka River.

26. *Etheostoma aspro* Cope & Jordan. Blacksided darter. (P.) Forty-nine specimens. The Table X contains details of counts and measurements of these specimens

Current Number of Specimens.	Length of Body in mm.	Length of Head in mm.	Scales on Lateral Line.	Anal Fin.	Dorsal Fin.	Current Number of Specimens.	Length of Body in mm.	Length of Head in mm.	Scales in Lateral Line.	Anal Fin.	Dorsal Fin.
1	53	14.5	9-63-11	I-11	XIV-14	26	51	14	9-65- 9	II-10	XIV-14
2	42	11	9-61- 9	I- 9	XIV-13	27	47	12	9-61- 9	II- 9	XV -13
3	54	14	9-67- 9	I- 9	XIV-13	28	43	11	10-60- 9	II 9	XIV-14
4	35	10	9-66- 9	I-11	XIV-14	29	42	11	9-62- 9	II-10	XIV 13
5				I 10	XIII-13	30	52	13.5	9-68- 9	II 11	XV -13
6	52	13.5	9-63-10	I- 9	XIV-13	31	68	14	10-62- 9	II-10	XIV-13
7	55	13.5	9-67 9	I 11	XIV-14	32	52	13	9-63-10	II-10	XV -13
8	52	13	9-67- 9	I-10	XIII-14	33	47	12.75	9-62 9	II 10	XIII-14
9	62	15	9-70- 9	I-10	XIII-13	34	43	11	9-62- 8	II-10	XIV 13
10	44	11+	9-70- 7	I 10	XIII 13	35	43	11	9-66-10	II- 9	XV -13
11	40	10	9-64- 9	I-10	XV -14	36	44	11.5	9-62- 9	II-11	XIII-13
12	58	15	9-63- 9	I 11	XIII-14	37	51	13	10-70-10	II- 9	XIII 14
13	58	15	9-66- 9	I-10	XV -14	38	60	15.25	10-63- 9	II 10	XIV-13
14	56	15	9-69- 9	I 9	XV -14	39	59	15	9-67- 9	II- 9	XIII 13
15	44	11.5	9-66- 9	I-10	XIV-13	40	43	11	9-67- 9	II 10	XIV-14
16	52	13.5	9-65- 9	I 10	XIII-13	41	55	13.5	9-60- 9	II-10	XVI-13
17	33	8.5	9-59- 9	I- 9	XIII 13	42	43	11	9-63- 9	II 9	XII -13
18	43	11	9-66-10	I-11	XIII-13	43	37	10	-63-	II-10	XIII-13
19	43	11	8-63- 9	I-10	XV 14	44	47	12	9-68-10	II-11	XIV-14
20	41	10.5	9-63- 9	I-11	XIII 14	45	57	13	11-64- 9	II 10	XIII-14
21	43	11	9-61- 9	I 10	XV -14	46	41	10.5	11-68-10	II-10	XIV-13
22	56	15	9-65- 9	I-10	XIV 13	47	43	11	9-58- 9	II-10	XIV-1[illegible]
23	43	11	10-63- 9	I-10	XIV-14	48	45	11	-58- 9	II-11	XV -13
24	43	11	9-63- 9	I- 9	XIV-12	49	41	10.5	9-57 9	II- 9	XIII-15
25	51	13	11-69-10	I-11	XIV-13						

27. *Etheostoma phoxocephalum* Nelson. (P.) Six specimens.

28. *Etheostoma nigrum* Rafinesque. Johnny Darter. (P.) Forty-one specimens.

All the specimens had the cheeks, nape and breast naked and the opercles scaled. 20 had the belly naked, 12 partly and 4 completely scaled. Below is the table of counts for their scales along lateral line and the dorsal and anal fins. 36–10–46, for instance, stands for 36 scales with tubes, 10 without and 46 for the total along side:

Current Number of Specimens.	Scales Along Lateral Line.	Anal Fin.	Dorsal Fin.	Current Number of Specimens.	Scales along Lateral Spine.	Anal Fin.	Dorsal Fin.
1	40- 4-44	I-8	VIII-13	22	36-10-46	I- 8	VIII-12
2	39- 9-48	I-9	VIII-11	23	41- 2-43	I- 9	VIII-12
3	42- 6-48	I-8	IX -12	24	45- 1-46	I- 9	X -11
4	43- 6-49	I-8	IX -12	25	39- 6-45	I- 9	IX -12
5	44- 4-48	I-9	IX -13	26	47- 5-52	I-10	IX -13
6	40- 8-48	I-9	IX -12	27	35-13-48	I- 9	IX -13
7	43- 7-50	I-8	VIII-12	28	41- 4-45	I- 9	IX -13
8	44- 5-49	I-9	VIII-12	29	36-12-48	I- 9	VIII-13
9	43- 7-50	I-8	VIII-13	30	42- 7-49	I- 8	VII -13
10	40- 5-45	I-8	IX -12	31	43- 5-48	I- 9	VIII-13
11	44- 1-45	I-9	X -12	32	47- 5-52	I- 8	X -12
12	45- 0-45	I-9	X -14	33	42- 7-49	I- 8	VIII-12
13	33- 9-42	I-9	IX -12	34	43- 6-49	I- 9	VII -12
14	49- 1-50	I-9	IX -13	35	45- 0-45	I-10	VIII-13
15	45- 1-46	I-9	IX -13	36	45- 4-49	I- 9	X -13
16	42- 8-50	I-9	IX -13	37	37-10 47	I- 8	VIII-12
17	40-12-52	I-9	VIII-13	38	39- 5-44	I- 9	X -12
18	33- 9-42	I-8	VIII-12	39	42- 6-48	I- 9	VIII-12
19	45- 5-50	I-8	IX -12	40	43- 4-47	I- 9	X -12
20	45-10-55	I-8	VIII-12	41	44- 6-50	I- 9	IX -13
21	44- 5-49	I-9	X -12				

29. *Etheostoma camurum* (Cope.). (P.) 11 specimens.

Additional Notes on Indiana Birds. By A. W. Butler.

Each year observations on the birds of Indiana bring to notice interesting facts. This year has been no exception. The region covered by the reports of correspondents includes not only this State, but also Michigan and the part of Illinois and Ohio bordering on Indiana; therefore. I am enabled to add some valuable notes from neighboring localities that, while not within our limits, have a bearing upon the study of our birds.

The winter of 1894–5 was mild until after Christmas. From several localities in the State came information regarding the wintering of forms not commonly seen. Meadow Larks, Robins and Bluebirds were reported north of the latitude of Indianapolis. Yellow-rump Warblers and Golden-crowned Kinglets spent the

winter about Brookville. After a warm Christmas the weather changed. December 27 and 28, 1894, it became quite cold in this latitude. It remained warm generally over the Southern States. On January 24, 1895, the temperature as far south as South Carolina was near the zero mark. It turned warmer that night, and the next day, January 25, the weather was bright and clear. The day following was Friday. It rained, then snowed, the wind came down from the northwest with great velocity, the temperature fell rapidly, everthing was ice-bound or snowbound to the Gulf of Mexico, then followed weeks of unusual severity. The cold weather of April was also especially severe over the territory noted. The region affected is the winter home of numbers of our birds. There Robins, Bluebirds, Phœbes, Yellow-rump Warblers and House Wrens spend that season.

At the end of the severe weather in April, we are told, but few Robins and Bluebirds were to be found. The destruction of birds must have been enormous. The Bluebirds seem to have been almost exterminated. An observer living at Mt. Pleasant, S. C., says that when the April cold spell came millions of Robins were congregated in that vicinity and they perished by thousands. The severe weather had lasted so long and food was generally so scarce that they easily succumbed to the last effort of winter. The Yellow-rump Warbler and Hermit Thrush are reported also to have suffered severely. Perhaps other kinds of birds were also caught in that death dealing storm. The following notes on this and other subjects are brought to your attention:

1. *Sialia sialis* (Linn.), Bluebird.

Early in the spring of 1895 accounts of the scarcity of the Bluebirds began to be received. This scarcity was generally observed. Some of the particulars are here given.

At Redkey, Ind., Roy Hathaway says he saw two Bluebirds February 24; next seen April 7. He did not find a single pair breeding and only a few were seen, probably six or seven. He saw four Sunday, August 18; three of them he took to be young. He did not hear of any nests being found near there last spring.

At Greensburg, Ind., Prof. W. P. Shannon reports one seen February 24; next seen March 12. He notes it is becoming less common.

Mr. S. W. Collett, Upland, Ind., says: First seen March 25. Remarkably scarce. Have not seen more than a dozen.

Prof. Glenn Culbertson, Hanover, Ind. First seen February 23, one; next, February 28; next, March 1. Decreasing in numbers.

Angus Gaines, Vincennes, Ind., says they are absent this year.

A. B. Ghere, Frankfort, Ind., reports them extinct.

Jesse Earll, Greencastle, Ind., notes first one seen February 22; next, March 2. Decidedly scarce this summer.

Alexander Black, of the same place, says they have not appeared this year. He has not seen a dozen pairs all told.

Dr. Vernon Gould, Rochester, Ind. One reported March 19. One or two reported later. Have not seen or heard one this summer.

Mrs. Jane L. Hine, Sedan, Ind. First seen were two, March 29; next, April 2. Very rare. The whole country must report a loss of Bluebirds. Once in a great while one is seen. In a ride of twenty miles you may see none, or at best only one or two.

T. S. Palmer, Acting Ornithologist U. S. Department of Agriculture, Washington, D. C., informs me they received many reports of the unusual scarcity of Bluebirds last spring.

L. A. and C. D. Test, Lafayette, Ind., report one, the first, March 9; the next March 10. Strangely uncommon. Seemed very rare after the cold spell during the first half of March.

Clyde L. Hine, Waterloo, Ind. First seen, one, March 3; next, March 29; next, April 14. Very rare this spring.

Prof. A. L. Treadwell, Oxford, Ohio. Two seen January 1; next seen January 3, which was last one noted.

Prof. E. L. Moseley, Sandusky, Ohio. One, the first, seen February 22; next seen March 24. Not common this year.

E. M. Kindle, Franklin, Ind., says: The Bluebird seemed very scarce in Orange, Martin and Dubois counties, Indiana, this summer (1895).

B. T. Gault, Glen Ellyn, Ill., reported seeing but three at that place.

Ruthven Deane, Chicago, Ill., informs me he saw one at English Lake, Ind., but was not near enough to certainly identify it. He says all reports from this section show its extreme scarcity.

E. J. Chansler, Bicknell, Knox County, Ind., in a letter last spring, writes: Has been a resident until this spring, but has disappeared. Have not seen one the entire spring. Saw a dead one during the cold spell last winter. The past autumn he wrote: Have not been seen here since last February until about October 21. I have made numerous inquiries in regard to them, but can not learn of their breeding here this season.

T. L. Hankison, Agricultural College, Michigan: Heard one March 27. I have not seen a Bluebird this year, and know of only one other being seen.

W. De Clarenze, Brant, Saginaw County, Mich.: Two seen April 4; next seen April 10. For some reason Bluebirds are very scarce this season.

In the vicinity of Chicago, Ill., their absence was very noticeable.

Eliot Blackwelder, Morgan Park, Ill., informs me: Bluebirds have been extremely scarce this year. Have seen two single birds—March 28 and May 10; two pairs and one family of six. This makes in all twelve birds. Only one is recorded by the Chicago Academy of Science for Lincoln Park, Chicago. September 11 saw a flock of eleven sitting on a telegraph wire near my home. Last seen October 28.

L. A. and C. D. Test: Last seen (at Lafayette, Ind.) October 18. Usually abundant, but this year strangely rare. Have seen Bluebirds but twice, and am at a loss to account for their absence.

At Brookville, Ind., they were as abundant as usual in the fall and almost every nice day through November and December, 1894. After the severe weather last winter none were seen. Only a few were noted in the spring and none through the summer of 1895. I do not know that any bred here. This fall they have been more noticeable, but still are very rare. September 20 saw five in my garden with flock of sparrows. September 22 saw three, one adult, two young. November 2 saw four. November 4, quite a flock. November 23, one, the last.

2. *Turdus migratorius* (Linn.), American Robin.

Noticeably scarcer this year than usual. In some localities almost as few as Bluebirds.

Mrs. Jane L. Hine, Sedan, Ind., reports them not more than one-half to two-thirds as numerous as last year.

L. A. and C. D. Test, the past fall, say: Not as common as usual the past fall.

S. W. Collett, Upland, Ind., writes: Very scarce. A remarkable year for scarcity of Robins and Bluebirds. Have not seen more than a dozen of either kind.

Reported very scarce in and about Chicago, Ill. A daily paper there notes that but one Robin's nest was all that vigilant search revealed in Lincoln Park this year, where formerly there were hundreds of them. A single pair was seen in Oakwood Cemetery and three or four in Washington Park.

O. B. Warren, Palmer, Mich., says they were much scarcer than in 1894.

As to the general scarcity of certain birds, the following specific information will give some idea.

Alexander Black, Greencastle, Ind., says we did not have such numbers of warblers as we usually have. We saw a few Black-throated Green Warblers, a few Yellow-rump Warblers, and one or two Canada Warblers.

Mrs. Jane L. Hine, Sedan, Ind., says Bridge Pewees (Phœbes) were rare, Hermit Thrushes very rare, but Olive-backed and Wood Thrushes were common as ever.

Charles Clickener says Wrens and Catbirds were rare in Parke County this year.

At Palmer, Mich., O. B. Warren reports that many species were noticeably less common than in 1894. Among them were Golden-crowned Thrush, *Seiurus aurocapillus* (Linn.); Chestnut-sided Warbler, *Dendroica pennsylvanica* (Linn.); Black and Yellow Warbler, *Dendroica maculosa* (Gmel.); Yellow-rump Warbler, *Dendroica coronata* (Linn.); Black and White Creeper, *Mniotilta varia* (Linn.); Indigo Bunting, *Passerina cyanea* (Linn.); Junco, *Junco hyemalis* (Linn.); Pine Finch, *Spinus pinus* (Wils.); Red Crossbill, *Loxia curvirostra minor* (Brehm); White-winged Crossbill, *Loxia leucoptera* (Gmel.); Spotted Sandpiper, *Actitis macularia* (Linn.); Yellow-bellied Woodpecker, *Sphyrapicus varius* (Linn.); Flicker, *Colaptes auratus* (Linn.); Night Hawk, *Chordeiles virginianus* (Gmel.); Wood Pewee, *Contopus virens* (Linn.); Least Flycatcher, *Empidonax minimus* (Baird); Rusty Blackbird, *Scolecophagus carolinus* (Müll.). Especially rare were White-throated Sparrow, *Zonotrichia albicollis* (Gmel.); Nashville Warbler, *Helminthophaga ruficapilla* (Wils.); Winter Wren, *Troglodytes hyemalis* (Vieill.). Of the Hermit Thrush, *Turdus aonalaschkæ pallasii* (Cab.), he says there is a marvelous decrease in numbers, more noticeable than the absence of *Sialia sialis*.

E. J. Chansler, Bicknell, Ind., noted Phœbe, *Sayornis phœbe* (Lath.), and Eave Swallow, *Petrochelidon lunifrons* (Say), as scarcer than usual.

3. *Catharista atrata* (Bartr.). Black Vulture.

November 24, 1894, three seen at Monrovia, Morgan County, Ind.—Alden M. Hadley.

Large flocks observed at Bicknell, Ind., last fall (1895) feeding on dead hogs. —E. J. Chansler.

4. *Phalacrocorax dilophus floridanus* (Aud.). Florida cormorant.

Prof. Stanley Coulter informs me that there is a specimen in the collection of Purdue University, Lafayette, Ind., bearing the following legend: "Shot March, 1880, from amid a flock of wild ducks on bayou of Wild Cat Creek, Tippecanoe County, Ind., by Daniel Mueller, who donated the same to Purdue University."

5. *Phalacrocorax dilophus* (Sw. and Rich.). Double-crested Cormorant.

One shot November 28, 1895, on Big Walnut Creek, Putnam County, Ind.—Jesse Earll.

6. *Aquila chrysaëtos* (Linn.). Golden Eagle.

One measuring seven feet, two inches in extent was caught in a steel trap by Charles Fry, near Fairfield, Ind., December, 1895. The trap was set for skunks and was baited with rabbit.

7. *Pelecanus erythrorhynchos* (Gmel.). American White Pelican.

One shot in the Wabash River near Lafayette, Ind., about September 29, 1895. —L. A. and C. D. Test.

8. *Chen hyperborea* (Pall.). Lesser Snow Goose.

March 14, 1895, some sportsmen killed eight from a flock of twenty, near Greensburg, Ind. Those killed were immature, and the others seemed to be also. —Prof. W. P. Shannon.

9. *Anas penelope* (Linn.). Widgeon.

Since our last meeting records have been received of two more European Widgeons from Indiana. One, the second noted from the State, a young male, was killed in the Kankakee marshes, near English Lake, Ind. It was shot from a flock of Baldpates by Mr. J. F. Barrell, April 7, 1895. The specimen is now in the collection of Ruthven Deane, Chicago, Ill. Mr. Deane has also reported a specimen in the collection of Dr. Nicholas Rowe, of "The American Field," Chicago, Ill. It was killed at English Lake, Ind., in 1881 or 1882. This is the third record for Indiana, and the fifth for the interior of the United States. (The Auk, Vol. XII, No. 3, p. 292. See also Proc. Ind. Academy of Science, 1894, p. 78.)

10. *Calcarius lapponicus.* (Linn.) Lapland Longspur.

A hundred were seen at Morgan Park, Ill., October, 17, 1895, when it became abundant. Next seen October 26. Most abundant winter resident. —Eliot Blackwelder.

11. *Ammodramus caudacutus nelsoni.* (Allen.) Nelson's Sparrow.

Eliot Blackwelder, Morgan Park, Ill., reports it from that locality September 28, 1895. He says it is not common and breeds there.

12. *Ammodramus leconteii.* (Aud.). LeConte's Sparrow.

Mr. Blackwelder saw six at Morgan Park, Ill., April 21, 1895. He next noted them April 22. One day—the week of April 25—he shot three, and F. M. Woodruff, who was with him, shot another.

13. *Loxia curvirostra minor.* (Brehm.) American Crossbill.

There seemed to be a flock of seven on and near Purdue University campus (Lafayette, Ind.) which were observed on the following dates, 1895: March 30; April 3, 5, 6, 7, 10, 12, 13, 14, 15, 17, 18, 21, 23, 24, 25, 26, 29; May 1, 3, 4, 7, 11, 17, 18, 20, 21, 22. They may have remained later, but the observers were absent

after the last date. This fall these birds were seen November 5 (three), and heard November 26. (L. A. and C. D. Test.)

14. *Dendroica kirtlandi.* (Baird.) Kirtland's Warbler.

The second specimen of this rare warbler from Indiana was taken by the same person in the same vicinity as the first. W. O. Wallace obtained it near Wabash, Ind., May 7, 1895. Mr. Wallace writes: "Early in the morning I heard a strange song in the thicket near the house, but I was very busy and did not go to see the singer for some time. It kindly remained until I completed my work, when I located it. Had it not been for its loud and peculiar song I should have pronounced it a Canada Flycatcher. Its song sealed its fate. After watching it catch insects and listening to its song for some time, I backed off and shot it. Imagine my surprise when I held in my hand my second Kirtland's Warbler. The song bears considerable resemblance to that of the Great Carolina Wren and also suggests that of the Maryland Yellow-throat. It is loud and rather musical. I noticed in both specimens movements more like the Flycatchers than the Warblers."

Notes on Parasites Collected in the State in 1895. By A. W. Biting.

I have only a few parasites to report as additions to the list presented last year. Some of these are very common and it now seems strange that they were not collected before.

Gastrophilus hæmorrhoidalis was taken in the mature state during the summer.

Trichodectes parumpilosus Piaget taken last spring. It is the common biting louse of the horse.

Pulex was taken on *Scalops aquaticus*, Cuv. Only a few specimens of this parasite have ever been collected.

A species of Ixode was taken from *Spermophilustridecum lineatus.*

A species of *Pulex* was taken from the same host.

Strongylus paradoxus was recently obtained from hogs thought to be affected with cholera.

Amœba meleagridis was found in the liver of a turkey on December 25.

Trichocephalus affinis was obtained from the intestines of the sheep.

A Report Upon Certain Collections of Phanerogams Presented to the State Biological Survey. By Stanley Coulter.

During the past year the Survey has come into possession of three collections, embracing nearly one thousand species, which serve as a good foundation for the proposed herbarium. The specimens are unmounted and provision should be made in the near future for their permanent preservation. The collections, while representative, contain but a scant series of duplicates, so that at present the proposed distribution into sets is impossible. Much fuller collections must come into the hands of the Survey before this work can be undertaken.

The material has been derived chiefly from three sources:

1. A collection of about 500 species, selected from the duplicates of the herbarium of Purdue University. This represents for the most part forms of general distribution, although containing such exceptional forms as *Leavenworthia Michauxii*, *Sullivantia Ohionis* and *Brachychaeta cordata*.

2. A collection of 163 species from the Rev. E. J. Hill, of Englewood, Illinois. This collection is of especial value, since it is made up almost entirely of plants of exceptional or limited distribution. A fuller idea of the value of this collection may be gathered from an examination of the paper on *Noteworthy Indiana Phanerogams* (these Proceedings, p. —), to which reference is made.

3. A collection of some 300 species from Mr. H. J. Clements, of Washington, Daviess County. The collection of Mr. Clements was confined to the immediate vicinity of Washington, and the extent of the collection, the accuracy of determination and the completeness of the accompanying data are sufficient proofs of Mr. Clements' ability. As the collection stands for a new region, concerning which it is extremely desirable to have a full knowledge, I have made from the material furnished by Mr. Clements a provisional list of the flora of the vicinity of Washington. Some thirty sheets, chiefly *Asters*, are as yet undetermined. In the work of studying this collection I have been greatly aided by Miss Alida M. Cunningham, to whom the Survey is indebted for much critical work in the examination of Indiana forms.

The sedges and grasses have passed through the hands of Prof. J. Troop, to whom acknowledgment is thus made.

Until such time as the Directors of the Survey have determined the form in which the State flora shall appear it has been thought best to follow the nomenclature of Gray's Manual, sixth edition.

Provisional List of the Phanerogams in the Vicinity of Washington, Daviess County, Indiana. Based upon the collections of Mr. H. J. Clements, during the seasons of 1894 and 1895:

RANUNCULACEÆ.

Clematis Pitcheri Torr and Gray. (104.) "Near Prairie Creek, near B. & O. R. R. July 4, 1894."

Anemone Virginiana L. (99.) Woods south of Oak Grove and B. &. O. R. R. July 4, 1894.

Anemone Pennsylvanica L. (81.) Abundant on north side of B. & O. R. R. west of Oak Grove.

Anemonella thalictroides Spach. (17.) Rare. Woods west of Washington. April 13, 1895.

Thalictrum dioicum L. (54.) Sanford's Woods. May 4, 1895.

Thalictrum purpurascens L. (79.) South bank of railroad track, south of Oak Grove. May 18, 1895.

Ranunculus multifidus Pursh, var. *terrestris* Gray. (87.) First wood south of B. & O. R. R. and west of Oak Grove. May 18, 1895.

Ranunculus abortivus L. (13.) Common in wet places. B. & O. Railroad west of shops. April 5, 1894.

Ranunculus recurvatus Poir. (55.) Sanford's woods. May 14, 1894.

Ranunculus septentrionalis Poir. (27.) Common, hillsides in woods, low places, etc. April 20, 1894.

Ranunculus repens L. (80.) Hyatt's, south of B. &. O. Railroad. May 18, 1895.

Isopyrum biternatum Torr and Gray. (12.) Woods south of B. & O. shops. April 13, 1894. This form was referred by Mr. Clements to *Thalictrum clavatum*, DC., which does not occur in Indiana.

Delphinium tricorne Michx. (39.) Sanford's woods. April 21, 1894.

Actaea alba Bigel. (40.) Woods south of B. & O. Railroad and Oak Grove. April 27, 1894.

Hydrastis Canadensis L. (33.) Hyatt's woods, south of B. & O. shops. April 27, 1894.

MENISPERMACEÆ.

Menispermum Canadense L. (213.) South of Oak Grove. May 18, 1895.

BERBERIDACEÆ.

Podophyllum peltatum L. (34.) All woods. April 27, 1894.

PAPAVERACEÆ.

Sanguinaria Canadensis L. (11.) Common. Sanford's woods. East of Washington. April 5, 1894.

FUMARIACEÆ.

Dicentra Cucullaria DC. (20.) Hyatt's woods, south of B. & O. shops. April 14, 1894.

CRUCIFERÆ.

Dentaria laciniata Muhl. (14.) Woods south of Oak Grove. April 5, 1894.

Cardamine rhomboidea DC. (24.) Bretz's pasture, damp places along branch. Rather common. April 20, 1894.

Cardamine rhomboidea DC., var. *purpurea* Torr. (5.) Woods south of B. & O. Railroad at Oak Grove, two miles west of Washington. April 2, 1894.

Cardamine hirsuta L. (7.) Thin woods along Prairie creek. April 4, 1894. The determination is apparently correct, but the specimen sent the Survey is too immature for absolute certainty.

Draba Caroliniana Walt. (8.) One specimen found along fence row, about 3½ miles north or northwest of Washington. April 4, 1895.

Sisymbrium officinale Scop. (145.) Common everywhere. August 4, 1895.

Brassica nigra Koch. (136.) Escaped about gardens, etc. July 29, 1895.

Lepidium Virginicum L. (124.) Common weed. July 29, 1895.

CAPPARIDACEÆ.

Polanisia graveolens Raf. (177.) Along B. & O. track in West Washington. July 4, 1895.

VIOLACEÆ.

Viola palmata L. (47.) Sanford's woods. Common. May 4, 1894.

Viola palmata L., var. *cucullata* Gray. (19.) Hyatt's woods, south of shops. April 13, 1894.

Viola pubescens Ait. (18.) Hyatt's woods, south of B. & O. shops. April 13, 1895.

CARYOPHYLLACEÆ.

Saponaria officinalis L. (97.) Common along roadsides, etc. July 4, 1895.

Silene stellata Ait. (102.) South of Oak Grove and B. & O. railroad. July 4, 1895.

Silene Virginica L. (71.) Abundant. Woods south of B. & O. Railroad, Oak Grove and west.

Silene antirrhina L. (305.) Along railroad track in shop yard. May 11, 1895.

Lychnis Githago Lam. (214.) Grain fields; B. & O. track at Relay Station. May 18, 1895.

Cerastium arvense L., var. *oblongifolium* Holl. and Brit. (42.) Edge of Hawkin's creek, southwest of B. & O. shops. April 27, 1894.

PORTULACACEÆ.

Claytonia Virginica L. (1.) Common with flower parts multiplied. Abundant later in all woods and meadows. March 30, 1894.

HYPERICACEÆ.

Hypericum maculatum Walt. (135.) Roadside, northeast of Washington. July 10, 1895.

MALVACEÆ.

Malva rotundifolia L. (288.) About dwellings. September 28, 1894.

Sida spinosa L. (208.) Weed about gardens and yards. September 28, 1894.

Hibiscus lasiocarpus Cav. (161.) Roadsides, one or two miles north of Washington. August 5, 1895.

Hibiscus militaris Cav. (162.) Bank of Swan pond. August 5, 1895.

TILIACEÆ.

Tilia Americana L. (82.) Bank of White River, Hyatt's. Not common. May 18, 1895.

GERANIACEÆ.

Geranium maculatum L. (31.) Sandford's woods. April 27, 1894.

Geranium Carolinianum L. (243.) Waste ground, side of streets, etc. May 4, 1895.

Oxalis violacea L. (57.) Bretz' pasture. May 4, 1895.

Oxalis corniculata L., var. *stricta* Sav. (52.) Common everywhere. May 4, 1895.

Impatiens fulva Nutt. (126.) John Hyatt's woods. July 10, 1895.

CELASTRACEÆ.

Euonymus atropurpureus Jacq. (175.) Bank of Prairie Creek on B. & O. Railroad. July 4, 1895.

RHAMNACEÆ.

Ceanothus Americanus L. (103.) Woods south of B. & O. Railroad and Oak Grove. Herbaceous above, but drying down to wood base in winter.

VITACEÆ.

Vitis cordifolia Michx. (77.) Close to White River, near B. & O. bridge. May 18, 1895.

SAPINDACEÆ.

Negundo aceroides Moench. (83.) Near White River, along or near B. & O. track. May 18, 1895.

POLYGALACEÆ.

Polygala Senega L. (89.) Hyatt's woods, south of B. & O. Railroad. Also south of Oak Grove. May 18, 1895.

LEGUMINOSÆ.

Trifolium arvense L. (110.) About old canal, near B. & O. Railroad. July 4, 1895.

Trifolium pratense L. (237.) Waste places, roadsides, etc.

Petalostemon violaceus Michx. (165.) Roadside, Swan pond road. August 5, 1895.

Robinia Pseudacacia. (56.) Bretz' pasture. May 8, 1895.

Desmodium nudiflorum DC. (142.) Woods south of Oak Grove, and all woods. A nuisance. July 29, 1895. (223.) Fruiting specimen, August 10, 1895.

Desmodium acuminatum DC. (143.) Woods south of B. & O. Railroad and Oak Grove. July 29, 1895.

Desmodium pauciflorum DC. (174.) Woods two miles east of Washington. July 16, 1895.

Cercis Canadensis L. (28.) South of Oak Grove. April 23, 1894.

Cassia Marilandica L. (141.) Woods south of B. & O. Railroad at Oak Grove. July 29, 1895.

Cassia Chamæcrista L. (144.) Woods south of Oak Grove and B. & O. Railroad. July 29, 1895.

Gleditschia triacanthos L. (138.) Near Washington; no special habitat. July 29, 1895.

ROSACEÆ.

Prunus serotina Ehrh. (43.) Bretz' pasture. May 4, 1894.

Spiræa tomentosa L. (155.) Woods south of Oak Grove and B. & O. Railroad. July 29, 1895.

Geum album Gmelin. (130.) Very common in moist woods. July 10, 1895.

Fragaria Virginiana Mill., var. *Illinoensis* Gray. Railroad track and woods south of Oak Grove. May 11, 1895.

Potentilla Canadensis L. (44.) Bretz' pasture. May 4, 1894.

Agrimonia Eupatoria L. (149.) Woods south of B. & O. Railroad and Oak Grove. July 29, 1895.

Rosa humilis Marsh. (180.) South of Oak Grove. July 10, 1895.

SAXIFRAGACEÆ.

Hydrangea arborescens L. (128). Sanford's woods. July 10, 1895.

CRASSULACEÆ.

Penthorum sedoides L. (168.) Grassy pond. August 5, 1895.

LYTHRACEÆ.

Lythrum alatum Pursh. (101.) Two miles east of Washington on B. & O. Railroad. July 4, 1895.

ONAGRACEÆ.

Œnothera fruticosa L. (151.) Woods south of Oak Grove. July 29, 1895.

Circæa Lutetiana L. (113.) John Hyatt's woods. July 13, 1895.

CUCURBITACEÆ.

Echinocystis lobata Torr. and Gray. (275.) Along ditch south of B. & O. shops, September 28, 1894.

UMBELLIFERÆ

Daucus Carota L. (93.) Along ditches beside B. & O. track. May 18, 1894. (210.) Along B. & O. track. September 28, 1894.

Zizia aurea Koch. (92.) Along railroad track, edge of woods west of Washington. May 18, 1895.

Erigenia bulbosa Nutt. (2.) Beech woods, Hyatts, just south of B. & O. shops. March 30, 1894.

CORNACEÆ

Cornus florida L. (35.) Rather common. Hyatt's woods, south of shops. Some with pink involucre, April 27, 1894.

CAPRIFOLIACEÆ.

Triosteum angustifolium L. (254.) Hyatt's.

RUBIACEÆ.

Cephalanthus occidentalis L. (111.) Bank of Prairie Creek and B. & O. railroad. July 4, 1895.

Spermacoce glabra Michx. (170.) On side of Swan pond road. August 5, 1895.

Galium circæzans Michx. (188.) South of Oak Grove. May 18, 1895.

Galium trifidum L. (120.) Woods south of Oak Grove. Common. July and August.

Galium concinnum Torr and Gray. (181.) South of B. & O. railroad at Oak Grove. June 29, 1895.

COMPOSITÆ

Elephantopus Carolinianus Willd. (226.) Woods south of B. & O. railroad at Oak Grove. August 10, 1895.

Vernonia fasciculata Michx. (273.) Fields and roads. September 28, 1895.

Eupatorium purpureum L. (225.) Woods south of Oak Grove and B & O. railroad. Six to eight feet high. August 10, 1895.

Eupatorium perfoliatum L. (221.) Woods south of Oak Grove. August 10, 1895.

Eupatorium ageratoides L. (200.) Woods south of Oak Grove. September 28, 1894.

Eupatorium cœlestinum L. (232.) Near B. & O. shops, and in other places. August 22, 1895.

Solidago cæsia L. (199.) Woods south of Oak Grove. September 28, 1895.

Solidago Canadensis L. (274.) Waste fields, fence rows, etc. September 28, 1894.

Aster lævis L. (199 and 283.) Field west of B. & O. shops. September 28, 1894.

Antennaria plantaginifolia Hook. (25.) Abundant in patches. Bretz's pasture. April 20, 1894.

Gnaphalium polycephalum Michx. (206.) Field west of Washington. September 28, 1894.

Ambrosia artemisiæfolia L. (279.) Fields everywhere. September 28, 1894.

Heliopsis lævis Pers. (191.) Woods south of Oak Grove. September 28, 1894.

Rudbeckia hirta L. (179 and 190.) Woods south of B. & O. Railroad and at Oak Grove. July 4, 1895.

Helianthus divaricatus L. (156.) Woods south of B. & O. Railroad and at Oak Grove. July 29, 1895.

Helianthus hirsutus Raf. (271.) Woods south of Oak Grove. July 29, 1895.

Helianthus decapetalus L. (247.) Woods south of Oak Grove. August 15, 1895.

Bidens connata Muhl. (194.) Woods south of Oak Grove. September 28, 1895.

Helenium autumnale L. (204.) Railroad track near Oak Grove. September 28, 1894.

Achillea Millefolium L. (212.) Along railroad near Oak Grove. Common along roads. August 4, 1895.

Chrysanthemum Leucanthemum L. (94.) Railroad bank, west of Oak Grove. Edge of woods. June 8, 1894.

Tanacetum vulgare L. (159.) Roadside, about one mile north of West Washington. August 5, 1895.

Senecio aureus L. (88.) Hyatt's, south of B. & O. Railroad. May 18, 1895.

Cacalia atriplicifolia L. (158.) Woods south of B. & O. Railroad and Oak Grove. July 29, 1895.

Arctium Lappa L. (236.) Waste places. August 16, 1895.

Cnicus lanceolatus Hoffm. (239.) Vacant lots, etc. August 16, 1895.

Cnicus altissimus Willd. (192 and 272.) Railroad track west of shops. September 28, 1894.

Krigia amplexicaulis Nutt. (66.) Woods south of Oak Grove. May 11, 1895.

Lactuca Canadensis L. (281.) Along fence rows, etc. September 28, 1894. No. 137 also in all probability belongs here, although the form is too immature for accurate determination.

LOBELIACEÆ.

Lobelia cardinalis L. (163.) Edge of Swan pond. August 5, 1895.

Lobelia syphilitica L. (188a.) On same sheet with No. 188 and probably the same data.

Lobelia puberula Michx. (188 and 205.) Yard, corner E. 6th and Vantrus Sts.; near ditch west of shops. September 28, 1894.

Lobelia inflata L. (148.) Woods, south of Oak Grove. July 29, 1895.

CAMPANULACEÆ.

Specularia perfoliata DC. (219.) Side bank of B. & O. track at Hyatt's. June 15, 1895.

Campanula Americana L. (114.) John Hyatt's woods. July 17, 1895.

PRIMULACEÆ.

Steironema ciliatum Raf. (100.) Hyatt's woods and B & O. tracks. July 4, 1895.

APOCYNACEÆ.

Amsonia Tabernæmontana Walt. (86.) Abundant along Prairie Creek, south of B. & O. tracks. May 18, 1895.

Apocynum cannabinum L. (176.) Along railroad in wet places. July 4, 1895.

ASCLEPIADACEÆ.

Asclepias tuberosa L. (109.) Common south of Oak Grove, and B. & O. Railroad. July 4, 1895.

Asclepias purpurascens L. (186.) South of Oak Grove and B. & O. Railroad. June 1, 1895.

Asclepias incarnata L. (266.) John Hyatt's woods. July 14, 1895.

Asclepias Cornuti Decaisne. (263.) Along B. & O. Railroad, West Washington.

Asclepias variegata L. (185.) South of Oak Grove and B. & O. Railroad. June 1, 1895.

POLEMONIACEÆ.

Phlox paniculata L. (115.) John Hyatt's woods. July 13, 1895.

Phlox glaberrima L. (183.) Open woods, one-half mile west of Oak Grove. June.

Phlox pilosa L. (60.) South of Oak Grove. May 11, 1895.

Phlox divaricata L. (15.) Common, woods south of B. & O. shops. April 13, 1894.

Polemonium reptans L. (53.) Bretz' pasture. May 4, 1895.

HYDROPHYLLACEÆ.

Hydrophyllum appendiculatum Michx. (304). Hyatt's woods, south of B. & O. shops. June 1895.

Phacelia bipinnatifida Michx. (32.) Hyatt's woods, just south of B. & O. shops. April 27, 1894.

BORRAGINACEÆ.

Heliotropium Indicum L. (228.) Roadside three miles north of Washington. August 5, 1895.

Cynoglossum Virginicum L. (63.) Woods south of railroad at Oak Grove. May 11, 1895.

Echinospermum Virginicum Lehm. (258.) Woods two miles east of Washington. July 16, 1895.

Lithospermum canescens Lehm. (252.) South of Oak Grove, near railroad track. May 11, 1895.

CONVOLVULACEÆ.

Ipomœa purpurea Lam. (289.) Gardens, etc. September 28, 1894.

SOLANACEÆ.

Solanum nigrum L. (140.) Common about yards. July 29, 1895.

Solanum Carolinense L. (276.) Waste places. September 28, 1895.

Physalis Philadelphica Lam. (91.) Along B. & O. Railroad and in woods south of Oak Grove.

Physalis pubescens L. (139.) About yards. July 29, 1895.

Datura Stramonium L. (230.) Near Washington. September 28, 1895.

Datura Tatula L. (229.) Near Swan Pond. Not so common as No. 230. August 5, 1895. As Mr. Clements confused the two species the inference is that *Tatula* is the abundant form.

SCROPHULARIACEÆ.

Verbascum Blattaria L. (134.) Common in waste places. July 10, 1895.

Linaria vulgaris Mill. (244.) Common weed, lots and streets, September 10, 1895.

Scrophularia nodosa L., var. *Marilandica* Gray. (70.) Oak Grove on railroad track. May 18, 1895.

Pentstemon pubescens Solander. (189.) Railroad track south of Oak Grove.

Pentstemon lævigatus Solander, var. *Digitalis* Gray. (216.) Hyatt's. Wet places. June 6, 1895.

Mimulus alatus Ait. (164.) Prairie Creek bridge, Swan Pond road. August 5, 1895.

Veronica Virginica L. (95.) Along B. & O. railroad, two miles west of Washington. July 4, 1895.

Veronica peregrina L. (22.) Bretz's pasture. April 14, 1894.

Gerardia quercifolia Pursh. (171.) Woods south of B. & O., and Oak Grove. Flowers, lemon-color. Plant, six to eight feet high. August 10, 1895.

Gerardia purpurea L. (193). Woods south of Oak Grove. September 28, 1894.

BIGNONIACEÆ.

Tecoma radicans Juss. (96.) Along B. & O. tracks, west of Washington. July 4, 1895.

ACANTHACEÆ.

Ruellia strepens L. (303.) Abundant along Prairie Creek at Hyatt's. May 18, 1895.

VERBENACEÆ.

Verbena urticæfolia L. (285.) Common weed in waste places. September 28, 1894.

Verbena angustifolia Michx. (119.) Along railroad track east of Washington. July 16, 1894.

Verbena hastata L. (270.) Yard of B. & O. shops. August, 1895. (132.) Wilson's woods; wet places.

Verbena stricta Vent. (133.) Common plant along railroad and in vacant lots. July 10, 1895.

Verbena bracteosa Michx. (125.) Growing along sidewalks, etc. July 31, 1895.

Lippia lanceolata Michx. (122.) Common, growing along grassy fences and in pastures. July and August.

Phryma Leptostachya L. (131.) Sanford's woods. July 10, 1895.

LABIATÆ.

Teucrium Canadense L. (106.) South of B. & O. Railroad and Oak Grove. July 4, 1895.

Mentha piperita L. (150.) Along railroad tracks. July 29, 1895.

Lycopus rubellus Moench. (277 and 291.) Field west of B. & O shops. September 28, 1894.

Pycnanthemum lanceolatum Pursh. (173.) Abundant in waste lands two miles east of Washington. July 16, 1895.

Monarda fistulosa L. (105.) Woods south of Oak Grove. July 4, 1895.

Blephilia hirsuta Benth. (129.) Wilson's woods, along branch east of Washington. July 10, 1895.

Nepeta Glechoma Benth. (64.) West Eighth Street and B. & O. track. May 11, 1894.

Scutellaria lateriflora L. (169) Near Swan Pond. August 5, 1895.

Scutellaria canescens Nutt. (107.) Woods south of Oak Grove. July 4, 1895.

Scutellaria nervosa Pursh. (68.) Woods south of Oak Grove. May 11, 1895.

Brunella vulgaris L. (153.) South of B. & O. at Oak Grove. July 29, 1895.

Marrubium vulgare L. (168.) Swan Pond. August 5, 1895.

Lamium amplexicaule L. (248.) Side of northeast Sixth Street, near Walnut. May 11, 1895.

ILLECEBRACEÆ.

Anychia dichotoma Michx. (121.) South of B. & O. railroad at Oak Grove, in edge of woods.

Anychia capillacea DC. (264.) South of Oak Grove, near railroad.

AMARANTACEÆ.

Amarantus retroflexus L. (234.) Gardens, yards, etc. July.

Amarantus albus L. (211.) Weed about gardens. September 28, 1894.

Amarantus spinosus L. (209.) Weed in all gardens, etc. September 28, 1894.

CHENOPODIACEÆ.

Chenopodium album L. (290.) Common weed. September 28, 1894.

PHYTOLACCACEÆ.

Phytolacca decandra L. (147.) Common, roadsides, etc. July 29, 1895.

POLYGONACEÆ.

Rumex Britannica L. (238.) Waste places. August 16, 1895.

Rumex Acetosella L. (69.) Common everywhere in waste places. May 18, 1894.

Polygonum Pennsylvanicum L. (286.) Yards, etc. September 28, 1894.

Polygonum orientale L. (235.) Escaped from yards. August 16, 1895.

Polygonum Virginianum L. (146.) Woods south of Oak Grove and B. & O. Railroad. July 29, 1895.

Polygonum dumetorum L., var. *scandens* Gray. (117.) John Hyatt's woods and E. & I. Railroad. July 13, 1894.

ARISTOLOCHIACEÆ.

Asarum Canadense L. (85.) South of B. & O. tracks at Hyatt's. Not common. May 18, 1895.

SANTALACEÆ.

Comandra umbellata Nutt. (249 and 306.) Woods south of Oak Grove, where woods run into a low, grassy place. May 11, 1895.

EUPHORBIACEÆ.

Euphorbia Preslii Guss. (280.) Weed in waste places. September 28, 1894.

Euphorbia corollata L. (154.) Common along banks of B. & O. Railroad and woods south of Oak Grove. July 29, 1895.

URTICACEÆ.

Laportea Canadensis Gaudichaud. (116.) John Hyatt's woods. July 13, 1895.

Bœhmeria cylindrica Willd. (267.) John Hyatt's woods. July 13, 1895.

Parietaria Pennsylvanica Muhl. (267a.) John Hyatt's woods. July 13, 1895.

IRIDACEÆ.

Iris versicolor L. (72.) First pond beyond Oak Grove, south of B. & O. tracks. May 18, 1894.

Belamcanda Chinensis Adans. (127.) In pasture on Sanford's farm. July 10, 1895.

Sisyrinchium angustifolium Mill. (90.) Prairie Creek, west of Washington. May 18, 1895.

AMARYLLIDACEÆ.

Agave Virginica L. (233.) Near B. & O. Railroad, two miles east of Washington. Six to seven feet high. July 16, 1895.

DIOSCOREACEÆ.

Dioscorea villosa L. (59.) Woods south of B. & O. Railroad and Oak Grove. May 11, 1894.

LILIACEÆ.

Smilax herbacea L. (45.) Sanford's woods. Common in all woods. May 4, 1894.

Smilax Pseudo-China L. (78.) A vine covering a small tree. Bank of White River, north of B. & O. track. May 18, 1894.

Allium Canadense Kalm. (75.) Prairie Creek, south of B. & O. Railroad. May 18, 1894.

Camassia Fraseri Torr. (76.) Prairie Creek, south of Oak Grove. May 18, 1894.

Polygonatum biflorum Ell. (61.) Woods south of Oak Grove. May 11, 1894.

Polygonatum giganteum Dietrich. (253.) Beside railroad track near Oak Grove. May 18, 1895.

Asparagus officinalis L. (160.) About one mile north of West Washington. August 5, 1895.

Smilacina racemosa Desf. (46.) Sanford's woods. May 4, 1894.

Uvularia grandiflora J. E. Smith. (23.) Woods south of Oak Grove. April 21, 1894.

Erythronium Americanum Ker. (19a.) Hyatt's woods, south of B. & O. shops. April 14, 1895.

Erythronium albidum Nutt. (16.) Woods south of B. & O. shops. April 13, 1894.

Trillium sessile L. (74.) Hyatt's, south of B. & O. Railroad. Not common in this vicinity. May 18, 1894.

Trillium recurvatum Beck. (21.) Common in most woods. April 20, 1894.

Trillium erectum L. (30.) East of Washington. April 26, 1894.

COMMELINACEÆ.

Tradescantia Virginica L. (62.) Common. Railroad bank and woods south of Oak Grove. May 11, 1894.

ARACEÆ.

Arisæma triphyllum Torr. (38.) Hyatt's woods, south of B. & O. shops. April 27, 1894.

Arisæma Dracontium Schott. (73.) Prairie Creek, south of B. & O. Railroad. May 18, 1895.

ALISMACEÆ.

Sagittaria variabilis Engelm. (245.) Ditch, south of B. & O. shops. September 10, 1895.

CYPERACEÆ.

Cyperus strigosus L. (202.) Along ditch, west of shops. September 28, 1895.

Carex Grayii Carey. (300.) Wet places near B. & O. Railroad at Hyatt's. May 18, 1895.

Carex Shortiana Dewey. (301.) Hyatt's, near B. & O. Railroad. May 18, 1895.

Carex crinita Lam. (217.) Hyatt's. June 6, 1895.

Carex teretiuscula Gooden. (302.) Wet places near Hyatt's. May 18, 1895.

GRAMINEÆ.

Panicum microcarpon Muhl. (308.) Two miles east of Washington. July 4, 1895.

Cenchrus tribuloides L. (201.) Along railroad tracks. September 28, 1895.

NOTEWORTHY INDIANA PHANEROGAMS. BY STANLEY COULTER.

The ruling of the directors of the Survey that no form should be admitted to the catalogue of the flora of the State unless verified by actual specimens has led me as far as possible to secure first exceptional forms of limited range, in the hope that by a publication of the data concerning them the attention of collectors might be directed to them, and our knowledge of their distribution within the State be increased. The most notable collection of these exceptional forms that has come into the possession of the Survey was that received from Rev. E. J. Hill, of Englewood, Ill., embracing 163 species. All of the specimens were of extreme interest, and many of them represented the sole record for the State. The following notes are based very largely upon this collection, and most of the forms represent a southern extension of northern forms. It should be remembered, however, that, until we have a full knowledge of the isotherms of our country, statements as to "southern limit" and "northern limit" are merely terms of convenience, and do not necessarily involve any real extension of range.

A fuller knowledge of natural drainage systems, of prevailing winds at varying seasons and of numerous other physical conditions is necessary before we can properly undertake a definite limitation of the range of any plant form. In a limited area, in which there is a definite organization of work, it is possible to determine many of these conditions and by their record add much to the ease with which some of the problems of geographical distribution may be solved.

Another feature emphasized by this paper is the extreme importance of long-continued collections in the same region. The work of Mr. Hill in Lake County covers a period of twenty years and has resulted not only in the addition of many new forms to the State flora but in a thorough botanical knowledge of that portion of the State. The work of Mr. Van Gorder in Noble County, extending through ten years, has shown similar results. Many problems which present themselves can only be solved by work of this kind. The tendency of collectors in the past work of the State has been to cover large areas, rather than to study closely some definite regions. Closer attention should be given by all collectors throughout the State to mass distribution, as distinguished from the station at which the collection is made, and also to the collection of fruiting specimens.

A somewhat careful study of our State flora leads me to believe that many forms may be added if a more careful study is made of our marsh and lake forms and of those groups which are of difficult discrimination. Special studies should also be made during the coming season of definitely characterized regions, as, for

example, of the flora of lime-stone cliffs, of clay soils, of sand hills, etc. The work needed is not so much a collection of plants as a collection of *facts* verified by plants.

In the following notes I have not in all cases referred to Mr. Bradner's list of the plants of Steuben County, because I have had no opportunity to examine his collections. The references, save as indicated in the notes, are to material in the possession of the Survey. A large number of interesting forms of *Cyperaceæ* and *Gramineæ* have been omitted, because our knowledge of the distribution of these forms in the State is too scant to justify any conclusions concerning them.

Cardamine pratensis L. This rare Northern plant, which was included in the State catalogue, but of which no specimen had been preserved, is now definitely reported with verifying specimens from two localities. Wet banks of Calumet River, Miller's, Lake Co., June 6, 1893 (E. J. Hill); Section 5, York Tp., Noble Co., May 28, 1894 (W. B. Van Gorder). Mr. Van Gorder sent me specimens of this plant last June, at which time I determined it to be *C. pratensis* L., a determination which was later confirmed by a careful comparison with the material in the Gray Herbarium at Harvard University. Under date of November 6, 1895, Mr. Van Gorder writes as follows:

"*Cardamine pratensis* L. grows plentifully on a tract of wet land, three or four acres, in section 5, York Tp., Noble Co. This tract is a part of the Elkhart River flat. I had seen the plant for several years, and at a distance thought it *C. rhomboidea* DC. This last spring it was dry enough, and passing the place I determined to know for sure. It flowers from May 15 to June 10. The specimen sent you was collected May 28."

The manual range of the plant is, "Wet places and bogs, Vt. to N. J., Wis., and northward; rare."

The following local references which I was able to collate while at the Gray Herbarium during the past summer may serve to show the interest which attaches to this plant as a member of the Indiana flora:

State (Indiana) Catalogue, etc. Lake Co. P. 3.

Flora of Michigan. Wheeler, C. F., and Smith, E. F. "Bogs." Rare S., frequent in C. and common N. P. 14.

Flora of Minnesota. Warren Upham. Lake Superior to sources of Mississippi. North. (Houghton.) P. 24.

Flora of Nebraska. Samuel Aughey. Includes without note. P. 6.

Flora of Iowa. J. C. Arthur. Does not include.

Preliminary Catalogue of Anthophyta and Pteridophyta, etc. Torrey Botanical Club.—Includes without note.

Catalogue of Plants of New Jersey. N. L. Britton.—Cedar swamp at New Durham. Rare. P. 8.

Catalogue of Native and Naturalized Plants of the City of Buffalo and Its Vicinity. David F. Day.—Rare. S. E. portion of Buffalo, near West Seneca. P. 18.

Flora of Cook Co., Ill., and Part of Lake Co., Ind. Higley, Wm. K., and Raddin, Chas. S.—Calumet River, near Miller's, Ind.—Rare. April. (Bastin and Hill.) P. 9. This reference is evidently based upon the collection of Mr. Hill cited *supra.*

Plants of Illinois. H. N. Patterson.—Does not include.

Flora Peoriana (Ill.). Frederick Brendel.—Does not include.

Higher Seed Plants of Minnesota Valley. Conway Macmillan.—Does not include.

Catalogue of Canadian Plants. John Macoun.—"Wet, swampy meadows, Labrador; St. Patrick, Charlotte Co., N. B.; vicinity of Prescott Junction, three miles south of Ottawa; wet meadows and swamps, Hastings Co., Ont.; Whiskey Island; Georgian Bay; Hudson's Bay; throughout Arctic America and Greenland."

Manual and Instructions for Arctic Expedition, 1895. Hooker, on arctic plants, p. 203, says: "The most arctic plants of general distribution that are found *far* north in all the arctic areas are the following; all inhabit the Parry Islands or Spitzbergen or both." A list of fifty-three plants is given, including *Cardamine pratensis* L.

On page 226, the range of this form is given as "from Mackenzie's River to Baffin's Bay. Throughout Arctic Greenland."

In same volume, page 244, the following note concerning this form is given by James Taylor: " *Cardamine pratensis* L. Flowers June-July. East side Disco Island. Altitude, 200 feet. North lat., 69° 10′; W. long., 54° 30′."

In the various catalogues of the New England States it is usually included with the statement, "chiefly found in the northern part."

From these citations it will be seen that the Indiana stations mark the southern-central limit of this true arctic form, which in all probability found its way southward during the glacial period.

Arabis lyrata L. "Dry, sandy ground, Miller's, Ind., June 6, 1893." (E. J. Hill.) Reported also from Laporte County, presumably upon authority of Dr. Barnes, and included in Bradner's flora of Steuben County. The form in general is a northern one in its mass distribution, although extending south along the mountains as far as Kentucky. Its local distribution will probably be found to

be limited to the northern portions of the State, and its occurrence there can only be expected in exceptionally favorable localities.

Hudsonia tomentosa Nutt. "Sand hills, Miller's, Ind., June 20, 1893." (E. J. Hill.) This striking form has as yet its only station as indicated. It is so unlike the ordinary phanerogam of Indiana that it could scarcely have escaped notice if it was of any wide distribution. The range of the plant is "sandy shores, Maine to Md., and along the Great Lakes to Minn., rarely on streams inland." It is therefore probable that its distribution in Indiana is extremely restricted.

Lechea thymifolia Michx. "Sandy ground, Tolleston, Ind. Flowers collected Sept. 16, 1882; fruit, Oct. 1, 1881." This is the only record for the species, and if the determination holds good, is a rather peculiar extension of range. The assigned range is "dry grounds near the coast, E. Mass. to Fla." The reference is apparently accurate, but on account of the well-known difficulty of discrimination between the species of this genus, I am unable to feel absolutely certain in the absence of authenticated specimens for comparison. The authority of Mr. Hill, however, is sufficient to retain the plant in the State list until opportunity occurs for comparison with forms from the east.

Arenaria Michauxii Hook. f. "Dry sands, Clark, Ind., June 13, 1893." (E. J. Hill.) There seems to be no special reason why this species should not be found generally distributed throughout the State, although as yet this is the only station recorded. The known range of the plant easily includes Indiana, and it should be looked for throughout the State.

Arenaria lateriflora L. "Dry woods, Miller's, Ind., June 20, 1893." (E. J. Hill.) This species was reported by Dr. A. J. Phinney in his list of plants of the region covering Jay, Delaware, Randolph and Wayne counties. He, however, secured no verifying specimen. The Lake County collection, however, serves under the rules of the State to give the species a place in the flora of Indiana. It is probable that the plant will be found to occur only in the eastern and northern counties of the State, its general range being northward.

Hypericum Kalmianum L. "Wettish sands, Tolleston, Ind. Flowers collected June 29, 1880; fruit, September 3, 1880." (E. J. Hill.) Also collected at Laporte by Dr. C. R. Barnes. This species is evidently limited to the northwestern counties of the State and will probably not be found much beyond the lake region. The assigned range is Niagara Falls and northern lakes.

Linum sulcatum Riddell. "Dry, sandy soil, Pine Station, Ind., July 28, 1875." (E. J. Hill.) So far as I am able to determine, this is the only station

in the State for this species. Its general range, "E. Mass. to Minn., and southwestward," would indicate, perhaps, a more general distribution since it has made its appearance within our boundaries.

Nemopanthes fascicularis Raf. "Wet ground, Miller's, Ind. Flowers collected April 29 and May 11, 1882; leaves and fruit July 4, 1882." (E. J. Hill); Steuben County (E. Bradner). Although not included in the lists of Mr. Van Gorder, I have received from him this summer material of this species collected in Noble County. The manual range of the plant was extended upon the collection of Mr. Hill, and from the later reports it is fair to infer that its occurrence is limited to perhaps the northern tier of counties

Lathyrus maritimus Bigel. "Shores of Lake Michigan, Whiting, Ind., July 15, 1875." (E. J. Hill.) A species inhabiting the seashore from Oregon and New Jersey to the Arctic Ocean, and also found on the Great Lakes. The range in Indiana can evidently be but slightly extended, if at all.

Rosa Englemanni Watson. "Flowers collected, East Chicago, Ind., June 5, 1890; fruit collected in damp thickets at Pine Station, Ind., Aug. 25, 1891. Four feet to eight feet high." (E. J. Hill). The specimen furnished the survey seems clearly referable to this species, though showing a decided increase in size. The plant is normally from "three to four feet high, or less." Its range is given as "Whisky Island, Lake Huron, shores of Lake Superior, and west to the Red River valley, and in the mountains from N. Montana and N. Idaho to Colorado." Its appearance in Indiana is of extreme interest and adds a new station for the species.

Heuchera hispida Pursh. "Sandy, open grounds, Tolleston, Ind., June 20, 1893." (E. J. Hill.) This is an additional station for this species which was formerly reported only from Vigo County by W. S. Blatchley. It may be assumed that the form will be found in favored localities throughout the State. (Saxifragaceæ in Indiana, Proc. Ind. Acad. of Sci. 1894, p. 105.)

Sambucus racemosa L. "Open woods, Porter, Ind., May 17, 1890; fruit, Otis, Ind., May 21, 1881" (E. J. Hill); "common at least in eastern part of Noble County" (Van Gorder); Steuben County (Bradner); Putnam County (MacDougal); Jefferson County (J. M. Coulter); Clarke County (Baird and Taylor). This species is northern in its mass distribution and is more rarely found southward. In leaf, fruit and bark characters, it at times runs perilously close to *S. Canadensis* L. I have found the color of the pith to be by far the most satisfactory means of discrimination between the two forms. Although the assigned range includes Indiana, my own experience leads me, in the absence of verifying specimens from

other localities, to limit the distribution of the species to the northern portion of the State.

Linnaea borealis Gronov. "Moist, pine woods, Pine Station, Ind., June 7, 1884." (E. J. Hill.) This is the recorded southern limit for this definitely northern form. Its occurrence so far south is worthy of note. It must be remembered, however, in this extension of ranges that limits are marked by parallels of latitude, when the proper method would be a consideration of isothermal lines.

Galium boreale L. "Sandy prairies, Sheffield, Ind., July 6, 1875" (E. J. Hill); "rather common, Noble County" (W. B. Van Gorder). The distribution of this species seems fairly well made out for Indiana, being confined to the northern counties which represent in a general way its southern limits. It is a form that can not be readily mistaken for any other members of the genus, being definitely marked by its bright white flowers.

Liatris cylindracea Michx. "Dry sands. Lake County, Ind., September 4, 1893. (E. J. Hill.) The Indiana stations for this plant, so far as reported, in addition to that in Lake County, are St. Joseph County (C. R. Barnes); Gibson and Posey counties (J. Schneck). These widely separated stations indicate at least the probability of its occurrence throughout the State in favorable localities. The manual range reads: "Dry, open places, Niagara Falls to Minn. and Mo." The St. Joseph County record is verified by specimens in the Purdue Herbarium. The inclusion of the Gibson and Posey County station is upon the authority of Dr. J. Schneck, of Mt. Carmel, Ill.

Solidago humilis Pursh. "Sand hills, near Lake Michigan, Miller's, Ind., September 12, 1893. Sometimes 3 feet high." (E. J. Hill.) This is a distinctly northern form, and one which shows in its very considerable increase in size the effect of its new range. In its normal range, "Rocky banks, W. Vt., along the Great Lakes, and northward," it is a low plant from 6 to 12 inches high. At the base of the White Mountains a form is reported, by Gray, as occurring, having a "stout stem, 1-2 feet high." Variety *Gillmanni* Gray, is larger (2 feet high), but in addition to differences in inflorescence, is sharply separated from the species by its "laciniately toothed leaves." The species is undoubtedly a member of the State flora, and the Lake County station is to be added to the other exceptional stations recorded, "islands in the Susquehanna, near Lancaster, and at the Falls of the Potomac."

Solidago uliginosa Nutt. "Peat bogs. Pine Station, Ind., Sept. 11, 1890." (E. J. Hill.) This plant, which is northern in its mass distribution, has its southern limit, so far as reported, in the northern tier of counties of Indiana. Additional stations are, St. Joseph County (C. R. Barnes) and Noble County (W.

B. Van Gorder). Specimens have been examined from all three localities. The recorded range of the plant is "Peat bogs, Maine to Penn., Minn., and northward."

Brachychæta cordata Torr. and Gray. Among the forms that have come into the Indiana flora from the South the above is one of the most interesting. Its station is in Jefferson County, especially at Clifty Falls. The station is one of the remarkable ones in the State, because of the number of rare forms there found, *Sullivantia Ohionis* Torr. and Gray, being perhaps the most noteworthy if we except *Brachychæta.*

The manual range of the plant is as follows: "Wooded hills, S. Ind. and E. Ky. to N. Ga." In the Synoptical Flora, p. 161, the range is given as follows: "Open woods, etc., W. North Car. and E. Ky. to upper part of Ga." The plant was apparently first collected by Rafinesque, by whom it was described as *Solidago sphacelata*, Raf. Ann. Nat. (1820), p. 14.

In Short's Supplement to the Catalogue of the Plants of Kentucky it is described as *Solidago cordata* Short.

In DeCandolle's Prodromus, V. 313, it appears as *Brachyris ovatifolia* DC., with the range "*in agro Kentuckensi ad ripas fluminum legit*, cl. Rafinesque. * * Species, *distinctissima*."

Additional localities are as follows:

Flora of West Virginia. C. F. Millspaugh. P. 382.—"Fayette County, near Nuttalsburg, plentiful."

Flora of Southern United States. A. W. Chapman, 2d edition. P. 213, entered as *Solidago cordata* Short. "Mountains of Georgia and North Carolina and northward."

Botany of Southern States. John Darby. P. 370—"North Carolina and Northern Georgia."

A Sketch of Botany of South Carolina and Georgia. Stephen Elliott. Vol. II (1824), which includes Solidago, does not distinguish the form.

Tennessee Flora. August Gattinger (1887). P. 51—Records as occurring over the whole State.

The specimens in the Gray Herbarium only include four sheets, all being from the South. They are as follows:

Solidago cordata (n. sp.) Short. Cliffs of Kentucky River. C. W. Short, M. D., Lexington, Ky. This is the type specimen of *Brachychæta cordata* Torr. and Gray.

Solidago cordata Short, Wilkes County, North Carolina, M. A. Curtis; Table Mountain, North Carolina, M. A. Curtis. Both of these have received the label *Brachychæta cordata* in the handwriting of Dr. Gray.

Solidago cordata Short. French Broad River, 1843. No collector's name.

Brachychæta cordata Torr. and Gray. Curtiss, North American Plants, No. 1298; Bluffs of Cumberland River, near Nashville, Tenn. Legit A. Gattinger.

An examination of the above data shows that this form can be reasonably expected in the southwestern counties of the State. It is easily mistaken for a Solidago, which genus it resembles closely in head and flower, except in the pappus. It perhaps should be looked for in collections among the Solidagos.

Aster polyphyllus Willd. "Grassy borders of low thickets, Whiting, Ind. September 29, 1892." (E. J. Hill.) The range of this species being "northern Vermont to Wisconsin, and southward," it is a little remarkable that this is its only record for the State. It is possible that it has been mistaken for *A. ericoides* L., which it resembles in many particulars. The extreme variability of this latter form renders such an error a natural one. It is probable that *A. polyphyllus* is more widely distributed throughout the State than the single recorded station would indicate.

Aster umbellatus Mill. "Moist grounds, Pine Station, Ind. September 4, 1893." (E. J. Hill.) This form, "common, especially northward," is only recorded from four counties of the State. Additional stations are as follows: Jefferson County (C. R. Barnes); Clark County (Baird and Taylor); Jay County (Dr. Phinney). The Jefferson County reference has its authentication in specimens in the Purdue Herbarium; the Clark and Jay County stations rest upon the authority of the collectors. The plant may be confidently looked for in the northern counties of the State, and many new stations should be added as a result of the work of the ensuing season.

Aster ptarmicoides Torr. and Gray. "Dry sands, Pine Station, Ind." (E. J. Hill.) This form, occurring on "dry rocks, western New England to Minnesota, along the Great Lakes, and northward," is another species that has entered the State from the north. The Lake County station is the natural one for the State. In the fall of 1894, Messrs. Conner and Laben collected this species at Happy Hollow, Tippecanoe County. I withheld judgment upon the determination, until I was able to examine the type specimens in the Gray Herbarium. There is no question that *A. ptarmicoides* occurs in Tippecanoe. The station in which it is found is so secluded as to preclude the probability of its recent introduction. The range of the species must therefore be extended somewhat.

Echinacea angustifolia DC. "By Michigan Southern and Lake Shore Railroad, Durham, Ind. In a prairie. July 4, 1892." (E. J. Hill.) So far as I am able to find, this is the only record for this species in the State. The form has evidently entered our flora from the west, its recorded range being "Plains from Ill. and Wisc. southwestward." It is easily distinguishable from *E. purpurea* Moench. and should be looked for carefully in the western counties of the State.

Artemisia Canadensis Michx. "Shores of Lake Michigan, Lake Co., Sept. 4, 1893." (E. J. Hill.) This northern form has its only recorded station for Indiana in the above reference. Its range is "Northern New Eng. to the great lakes, Minn., and northward." It is closely allied to *A. caudata* Michx., which also has its sole Indiana station in Lake Co. No specimen of this latter form, however, has as yet been obtained by the Survey. *A. caudata* having a range "Mich. to Minn., and southward," should be found, at least, in the northern counties of the State. Both species are separated from the other Artemisias by their *dissected leaves* and should be readily recognized.

Cnicus Pitcheri Torr. "Sandy shores of Lake Michigan, Pine Station, Ind., June 21, 1891." (E. J. Hill.) This well-marked species has this as its only station in the State, so far as the records indicate. Its range, "Sandy shores of Lakes Michigan, Huron and Superior," would indicate but a slight probability of any material increase in its distribution. It would probably be found in Laporte County in the region of Michigan City, if careful search were made. With its cream-colored flowers and white woolly covering it is an extremely attractive form and could scarcely be mistaken for any other species of the genus.

Cnicus pumilus Torr. "Pine barrens. Lake County, Ind., July 4, 1891." (E. J. Hill.) This form is labeled *Cnicus Hillii* W. M. Canby. I am unable, however, to see any reason why the form should not be referred to *C. pumilus* Torr., and in the absence of Mr. Canby's original description I have so referred the specimen sent to the Survey. Certain variations from the type seem to me easily referable to geographical causes, and not of sufficient importance to necessitate the establishment of a new species. The range of the plant, "Dry fields, N. Eng., near the coast. to Penn.", seems to me to furnish the only argument against the reference. It is possible that more abundant material may lead to a different conclusion. The reported occurrence of *Cnicus pumilus* in Dearborn County (S. H. Collins) is not authenticated by specimens, and is in all probability an error in determination. The extension of the range of a coast plant to the Great Lakes could be easily accounted for, but its extension to Dearborn County without intervening stations would be difficult of explanation.

Prenanthes racemosa Michx. "Open, grassy land, East Chicago, Ind., Oct. 5, 1892." (E. J. Hill.) Noble County (W. B. Van Gorder). The range of this species in Indiana seems to be limited to the northern tier of counties. The form is found in "plains, N. Maine to N. J. and northward," though extending also into Missouri. It is easily distinguished from the other species of the genus found in the State by its heads being in crowded clusters, and could scarcely have escaped the attention of collectors had it been of any general distribution.

Pyrola chlorantha Swartz. "Sandy woods, Whiting, Ind., May 25, 1878." (E. J. Hill.) A northern form, ranging from Labrador to Minnesota, northward and westward, with the single record from Indiana as indicated. The specimens in the possession of the Survey are, so far as known, the only ones from the Indiana station in the herbaria of the State.

Trientalis Americana Pursh. "Damp woods, Miller's, Ind., May 11, 1878." (E. J. Hill.) "In tamarack marshes in moss near the roots of trees. Very common in some places. Noble County." (W. B. Van Gorder.) The mass distribution of this species is decidedly northern, its southern limit being the northern tier of counties in Indiana, save where it extends southward along the mountains. It will probably be found in all of the northern counties. but need scarcely be expected farther south.

Menyanthes trifoliata L. "Bogs and peat marshes, Pine Station, Ind. May 13, 1876." (E. J. Hill.) "Moist shores of lakes—very common at Pleasant Lake, Noble Tp., Noble Co." (W. B. Van Gorder.) While the sixth edition of Gray's Manual includes Indiana in the range of this species, its authenticated distribution is confined to the stations mentioned. It probably occurs throughout the northern portion of the State in favorable localities.

Convolvulus arvensis L. "By railroad, Pine Station, Ind. July 28, 1875. Rare." (E. J. Hill.) Also reported from Jay, Delaware, Wayne and Randolph Counties (Phinney), and Dearborn Co. (Collins). This adventive species, heretofore restricted to North Atlantic States, has evidently made lodgment in Indiana. I am inclined to think the Dearborn County reference somewhat doubtful, judging from the general range of the plant and taking into consideration the means of distribution to which the presence of this intruder is evidently due. I believe its range in the State will be found limited to the northern and central counties.

Stachys hyssopifolia Michx. "Wet, sandy banks, Laporte, Ind. July 22, 1875." (E. J. Hill.) Also collected at Laporte by C. R. Barnes. The State catalogue notes the plant as occurring from "Marion Co. and northward." The Marion County reference was doubtless based upon the authority of the late Dr. H. E. Copeland, who was an exceedingly keen observer, but who, unfortunately, left

no verifying specimens. It is scarcely possible that this can be the only station for the plant, since its range fairly covers the State.

Utricularia resupinata B. D. Greene. "Sandy margins of ponds, Whiting, Lake County, Ind., Aug. 16, 1883." (E. J. Hill.) This collection, upon which is based the extension of the range of this form in the 6th Edition of Gray's Manual (p. 735 c.), is only one of the many evidences of the critical work done by Rev. E. J. Hill and proof of the value of a long continued study of a single area. This same form was sent me last summer by W. B. Van Gorder from north shore of Bear Lake, Noble County, thus extending its local distribution.

Utricularia purpurea Walt. "Shallow ponds, Pine Station, Lake County, Sept. 13, 1879." (E. J. Hill.) This is another form shown by Mr. Hill to be a member of the State flora. This station for the plant is somewhat remarkable because it is so far *inland*. While the range is "ponds, Maine to Florida," it is limited by the additional statement, *usually near the coast*.

Utricularia gibba L. "Sandy, wet margins of ponds, Pine Station, Lake County, Sept. 13, 1879." (E. J. Hill.) While this plant would be naturally expected within our range, it has been but rarely collected in the State. The specimens furnished by Mr. Hill being the only ones I have seen from Indiana. It is especially desirable that close observations should be made in favorable localities in order that the distribution of these forms within the State may be determined.

Corispermum hyssopifolium L. "Dry, sandy ground, Pine Station, Ind., Sept. 4, 1893" (E. J. Hill.) The only reported station for this species. No great extension of its range throughout the State need be expected, since in our range it seems confined to the beaches of the Great Lakes, although farther west and south it is not so restricted. The form is presumably from the west, judging from available data.

Salsola Kali L., var. *Tragus*. This plant has undoubtedly obtained a sufficient foothold in the State to be included in its flora. It is, however, very doubtful if its spread will be sufficiently rapid to give it rank among our worst weeds. The plant is definitely reported from Clarke, Lake County, by E. J. Hill, and from Avilla, Noble County, by W. B. Van Gorder. Both collections are labelled "along railroad," indicating very clearly the method of introduction into our State flora. An examination of both specimens leads me to question the reference of the Lake County specimen. It does not agree in many particulars with the Noble County specimen, which latter is very plainly the typical variety *Tragus*, and so far as I am able to judge agrees more nearly with *Salsola Kali*. The extension of the range—"sandy seashore, New England to Georgia"— by the addition of "and along shores of Great Lakes" is a very natural one, but is apparently

incorrect because of the label, "along railroad." So far as I am able to learn, the plant has not spread with the rapidity to be expected from the variety *Tragus*. In view of the accuracy of Mr. Hill in all of his determinations, the Lake County station is admitted, with the suggestion that the plant in that particular locality needs a much closer study.

The Noble County plant is unmistakable, not only in its characters, but in its habits of growth. From facts ascertained through the work of Supt. Van Gorder, it is safe to say that if the Russian thistle spreads throughout Indiana it will be from the Noble County station as a center. The plant has been carefully watched since its first appearance in 1893, and efforts made to prevent its spread, though with no very great success, as the following letter indicates:

BRIMFIELD, IND., Nov. 3, 1895.

Mr. W. B. Van Gorder, Knightstown, Ind.:

DEAR SIR—In reply to yours of some time ago, will say that the Russian thistle came up again this year worse than last year. It was not cut soon enough, which, of course, scattered the seeds. I have not heard of it any place else yet. * * * * J. E. NISWANDER.

In the last map issued by the United States Department of Agriculture, showing the distribution of the Russian Thistle, a location is given in south-central Indiana. The map is, however, so small that I have not been able to locate the station, nor have I been able to discover upon what authority it was added.

In my opinion there are not more than two stations for the Russian Thistle in the State. Of these, that in Noble County alone seems to threaten any great spread of the pest. While the plant should be carefully watched, its general character as to periods of flowering and maturation of seed, taken in connection with the fact that though known to exist in Indiana since 1892, it has yet made no marked advance, would indicate that the danger from its introduction has been overestimated.

Polygonum tenue Michx. "Sand hills, Pine Station, Ind., July 28, 1875." (E. J. Hill.) Tippecanoe County, 1893. (Stanley Coulter.) This species has perhaps a more general distribution throughout the State than the references would indicate. Its normal range easily includes our territory, yet so far as I know no other stations are recorded. In a study of the genus *Polygonum* made recently I examined all of the collections in the State, and it is certainly not found in them from any other localities. The species is sufficiently characteristic to be easily separated from the more common forms, and could scarcely be confused with any other species, if we except *P. ramosissimum* Michx., from which it is readily distinguished by the character of the achenes.

Polygonella articulata Meissn. "Sand hills, Miller's, Ind , October 1, 1881. Flowers white or rose-colored." (E. J. Hill.) This seems to be the only authenticated station for this species. Mr. Van Gorder includes it in his list of plants of Noble County, published in pamphlet form in 1884, but excludes it from list published in 1887 in Eighteenth Report of the State Geologist. I infer from this that its inclusion in the first list was an error. Baird and Taylor also include it in their "Flora of Clark County," but as they made no collections the record is necessarily a doubtful one, with the probability against the accuracy of the determination. The assigned range is: "Dry, sandy soil; on the coast from Maine to New Jersey, and along the Great Lakes." It can be readily seen that its distribution in Indiana is in all probability limited to the northwestern counties.

Shepherdia Canadensis Nutt. "Sand ridges, usually near sloughs. Pine Station, Lake County, May 13 and 27, 1876." (E. J. Hill.) This attractive shrub has perhaps its southern station in this record. Its reported range is from "Vermont and New York to Michigan, Minnesota and north and westward." It is worthy of notice, perhaps, that in Indiana it occurs "near sloughs," while in other regions it is found chiefly on rocky or gravelly banks.

Euphorbia polygonifolia L. "Sandy shores of Lake Michigan, Lake County, Indiana, September 4, 1893." (E. J. Hill.) The range of this species is probably limited to the shores of Lake Michigan, at least so far as Indiana is concerned. While in general appearance it might be easily confused with other species, it is characterized by having seeds larger than those of any other species in section *Anisophyllum.*

Myrica asplenifolia Endl. "Sand hills, Miller's, Indiana. Flowers collected April 29 and May 30, 1882; fruit, July 4." (E. J. Hill.) This is the only locality for the State and it was upon this collection that the range of the species was extended in the sixth edition of Gray's Manual to include Indiana.

Betula papyrifera Marshall. "Sandy soil, Pine Station, Ind. Flowers collected May 13, 1876; fruit, September 3, 1876. Trees ten to thirty feet high." (E. J. Hill.) The material furnished the Survey was somewhat scant, but seemed sufficient to verify the determination. The petioles were shorter, perhaps, than in the normal form, but this seemed the only deviation from type in the leaf characters. The reduction in size from a tree fifty to seventy-five feet high in the normal range, to that indicated above, is the most marked feature in this extension of range. The form also occurs in northern Illinois, but I have no data at hand which indicate whether or not a similar reduction in size occurs. The species, as is well known, is northern in its general range.

Pinus Banksiana Lambert. "Sand barrens, Lake County, Ind., May 13, 1876." (E. J. Hill.) This is the only record for the gray or northern scrub pine in the State. The specimens sent the Survey establish the species as a member of the State flora beyond question. The inclusion is an extension of the reported range from Southern Michigan to Northern Indiana. It is a fact that in all probability more new forms will be added to the State flora by a careful study of our forest trees than from any other group of plants, if we except, perhaps, the water plants. For various reasons forest forms have received less attention and are more poorly represented in existing herbaria than any other. It is especially urged that during the ensuing season specimens of all forest trees be furnished the Survey by those interested in the work.

Orchidaceæ. Our knowledge of the occurrence and distribution of the various orchids of the State has been very greatly increased during the past year, a fact due largely to the labors of Messrs. Hill and Van Gorder. Both of these gentlemen have studied definite regions for years and have placed the Survey under many obligations for their careful and courteous responses to the many requests for information. I have asked Miss Alida M. Cunningham to collate the facts at hand, which she has done under the title "*Distribution of Orchidaceæ in Indiana,*" and reference is hereby made to that article (These Proc., p. —). I wish also, in this connection, to express the thanks of the botanical division of the Biological Survey to Miss Cunningham for the patient and efficient work she has done in the study and comparison of critical forms, which has done much to expedite the work of the division and has added greatly to the value of its final report.

Tofieldia glutinosa Willd. "Moist sands. Pine Station, Ind., July 28, 1875. (E. J. Hill.) The State Catalogue refers this species to the "northern tier of counties." This, however, is the only station in the state from which I have been able to secure herbarium specimens. It is included in the Flora of Noble County by W. B. Van Gorder (18th report of State Geologist, p. 66,) as growing in "moist grounds along the Elkhart river in Orange township, and is represented in Mr. Van Gorder's private herbarium. I know of no other stations in which the species occurs. The recorded range of the plant is "moist grounds, Maine to Minnesota, and northward; also south in the Alleghanies.

Triglochin maritima L. "Wet sands, border of slough, East Chicago, June 13, 1893." (E. J. Hill.) This species has been added to the state flora through the close work of Mr. Hill, who has recorded the only station for Indiana. The species is easily distinguished from the other members of the genus by its fruit of six carpels. The assigned range of the plant is, "salt marshes along the coast, Labrador to N. J., and in saline, boggy or wet places across the continent."

Potamogeton. Any systematist who has undertaken a study of this genus, will at once appreciate the fact that the value of specific determinations is largely increased if they have received the sanction of a specialist in the group. Mr. Hill's forms of this genus have undergone the scrutiny of the late Dr. Thomas Morong and may be added with confidence to the state flora. It is therefore with very great diffidence that I venture to question the determination of one or two of the sheets sent the Survey. The question is not of the original determination, but the suggestion is made that in the distribution there has been a confusion of forms. The most noteworthy species of this genus are the following:

P. pulcher Tuckerm. "Shallow ponds, Pine Station, Lake Co., June 21, 1884." (E. J. Hill.) From an examination of many specimens, I am led to believe that this form as received by the Survey should be referred to *P. amplifolius* Tuckerm, because of leaf and fruit characters. The range of the two forms is practically the same and it is possible that they may be found associated, and become mixed in distribution. The size of the fruit is perhaps the most apparent distinction between the two forms. In addition to *P. pulcher* Tuckerm, *P. amplifolius* Tuckerm is also without doubt a member of the state flora.

P. prælongus Wulf. Cedar Lake, Lake Co., Ind., Feb. 27, 1882. (E. J. Hill.) This well marked form should be more generally found in the northern counties of the State. The region is fairly within the range of the plant and the conditions for its occurrence are good. It has, however, been reported from no other locality, so far as I have knowledge.

P. Robbinsii Oakes. "Cedar Lake, Lake Co., Ind., June 30, 1886." (E. J. Hill.) This is another interesting northern form added to the Indiana flora as a result of Mr. Hill's indefatigable work. (Man. 6th edn. 735c.)

In the specimen sent the Survey by Mr. Hill, both fruit and flowers are absent. From this specimen standing alone, I would refer the form to *P. marinus* L., since the leaf and stem characters do not conform to the description of *P. Robbinsii.* My very high appreciation, however, of the skill and acuteness of Mr. Hill lead me to include the form *P. Robbinsii* Oakes, and also to add the species *P. marinus* L.

I am inclined to believe that a more careful study of the plants of our marsh and lake regions would result in the extension of the range of many forms in this and allied groups.

Eriocaulon septangulare Withering. "Sandy borders of ponds, Laporte, Ind., July 22, 1875. Scapes 6-8 striate." (E. J. Hill.) The addition of Indiana to the assigned range of this plant in the 6th edition of Gray's Manual was based

upon the collection of Mr. Hill. During the last summer Mr. Van Gorder collected it in Noble County, and Mr. Bradner includes in catalogue of the Flora of Steuben County (17th Report of State Geologist, p. 156), with the statement, "badly named, as the scape frequently has eight striae." The Hill collection is of the normal size from 2–6 inches high, while that of Van Gorder shows specimens from 1–2 feet high, having been submersed.

Distribution of the Orchidaceæ in Indiana. By Alida M. Cunningham.

The family of Orchidaceæ, as shown by the reports and specimens examined, is represented in the State by twelve genera and thirty-seven species.

Microstylis monophyllos Lindl., according to the 6th edition of Gray's Manual, is found growing in cold swamps in northern Indiana. It is also reported from the "Knob" region by Dr. J. M. Coulter. No specimen was examined.

Microstylis ophioglossoides Nutt., has been reported from Monroe by W. S. Blatchley, whose determination is verified by specimens in the DePauw Herbarium. One specimen of this species has been reported from Noble by W. B. Van Gorder and has been examined.

Liparis liliifolia Richard, occurs in the southern and central portions of the State. It is reported as rare in Franklin by O. M. Meyncke, but common in rich, shady woods in Gibson and Posey by Dr. Schneck. No specimens of this form have been examined.

Liparis Lœselii Richard, grows in extreme northern counties. Specimens from Lake by E. J. Hill and from Noble by W. B. Van Gorder were studied. Mr. Van Gorder states that it is very rare in that region and grows in tamarack marshes.

Aplectrum hiemale Nutt., is reported from the following counties: Clark, Jefferson and Franklin in the southeast; Gibson and Posey in the southwest; Putnam in the central; Noble and Steuben in the north. The State catalogue includes the species, referring it to Tippecanoe, but gives no authority for its inclusion. Specimens from Clark and Noble were the only ones studied.

Corallorhiza is represented in the State by three species—*innata*, *odontorhiza* and *multiflora*.

C. innata R. Brown. No Indiana specimen of this species was examined. It is reported, however, from the "knob" region by Dr. Clapp.

C. odontorhiza Nutt., is reported from Gibson and Posey by Dr. Schneck as rare, and found growing in shady woods in rich soil; from Franklin, by O. M. Meyncke; from Steuben, by E. Bradner, and from Noble, by W. B. Van Gorder, whose specimens were examined.

C. multiflora Nutt., is reported from Union by W. S. Blatchley, whose determination is verified by specimens in the DePauw Herbarium. From Noble, by W. B. Van Gorder, who states that it is rare in that county and grows in dry woods; and also from Steuben, by E. Bradner. The State catalogue includes this species, referring it to Jefferson, but gives no authority for its inclusion. No specimens were examined.

Spiranthes is said to be represented by four species: *latifolia*, *cernua*, *præcox* and *gracilis*.

S. latifolia Torr., is very limited in its range, at least as far as we have knowledge of its distribution. It is reported from Noble by Mr. Van Gorder, who states that only a few specimens were found. It is reported also from Tippecanoe by John Hussey, and his determination is verified by a specimen in the Purdue Herbarium.

S. cernua Richard, occurs chiefly in southern and western counties. It is reported also from Noble, where it grows with cranberry vines on the low shores of lakes.

S. præcox Watson, has been reported from Clark by Messrs. Baird and Taylor, and from Steuben by E. Bradner. The 6th edition of the Manual does not include Indiana in the range of this species, which reads: "Wet, grassy places, Mass. to N. J. and Fla."

S. gracilis Bigelow, is fairly well distributed, being reported from southeastern, northern and central counties, but is not found abundantly. Specimens from Noble, Lake and Jefferson were examined.

Goodyera repens R. Br., is reported from Steuben by E. Bradner. No specimens were studied, but the habit and range of the plant renders the determination doubtful.

Goodyera pubescens R. Br., has been collected in Noble by Mr. Van Gorder, whose specimen was examined. It is also reported from Warren and Vigo Counties.

Arethusa bulbosa L., is referred, in the State catalogue, to Lake Co. Dr. J. M. Coulter also reports it in the region of "Barrens." This would make it a true northern form and indicate that it grew in a cool climate and in both dry, sandy soil and low ground. No specimens were examined.

Calopogon pulchellus R. Br., is a northern species, being reported from St. Joseph by Dr. Barnes, whose specimen is in the Purdue Herbarium; from Steuben by E. Bradner, and from Noble by Mr. Van Gorder, who states that it is very abundant in that county and found growing in the same locality with *Pogonia ophioglossoides.*

Pogonia is represented by three species: *ophioglossoides, pendula* and *verticillata.*

P. ophioglossoides Nutt., is another true northern form. It is reported from Lake by E. J. Hill, from Noble by W. B. Van Gorder, who reports it to be very abundant and growing in cranberry marshes and low ground along the Elkhart River, and from Steuben by E. Bradner.

P. pendula Lindl., is reported from the extreme northern and extreme southern portions of the State. From Lake, by E. J. Hill, as very rare; Noble, by W. B. Van Gorder, as rare and growing in rich woods; Steuben, by E. Bradner; Gibson and Posey, by Dr. Schneck, as rare, growing in damp, rich woods, and from Jefferson, by Dr. J. M. Coulter.

P. verticillata Nutt., has been reported from three counties. From Monroe by W. S. Blatchley, Jefferson by Dr. Barnes, and from Noble by W. B. Van Gorder. Specimens from Noble and Jefferson were examined.

Orchis spectabile L., is the most widely distributed species in the family, being represented in twelve counties. It has been reported from the following: Jay, Delaware, Randolph and Wayne in the east; Jefferson, Clark and Monroe in the south; Noble and Steuben in the north; Putnam in the central; Franklin and Dearborn in the southeast.

Habenaria is represented by twelve species.

H. tridentata Hook., is reported from Lake by E. J. Hill whose specimen was examined.

H. virescens Spreng., is reported from Steuben by E. Bradner. No specimen of this species was examined, but its range would include it in the State list.

H. bracteata R. Br. Mr. Van Gorder reports three specimens of this species from Noble. Dr. Stanley Coulter says that it is fairly abundant in Tippecanoe, being reported by almost every class. Specimens from both counties were studied.

H. hyperborea R. Br., is referred to Lake in the State Catalogue, but no authority is given for its inclusion. It is probably, however, based upon the collection of E. J. Hill.

H. Hookeri Torr., is a northern form. Mr. Van Gorder reports it from Noble. A specimen from Lake by E. J. Hill was the only one studied.

H. orbiculata Torr., is also a northern species, being reported only from Noble, where it is very rare and grows in rich woods. A specimen from this county was examined.

H. ciliaris R. Br., is reported from St. Joseph by Dr. Barnes, from Noble by W. B. Van Gorder and from Steuben by E. Bradner.

H. leucophæa Gray, is reported from Noble by W. B. Van Gorder, from Steuben by E. Bradner and from White by J. Hussey.

H. lacera R. Br., is reported from Noble, where it grows in tamarack marshes.

H. psycodes Gray, is limited to the eastern half of the State, being reported from Jay, Delaware and Randolph by Dr. Phinney; Clark by Baird and Taylor; Jefferson by Dr. J. M. Coulter; Noble by W. B. Van Gorder and Steuben by E. Bradner.

H. fimbriata R. Br., has been reported only from Clark by Messrs. Baird and Taylor.

H. peramœna Gray, is a southern and western species. A specimen from Jefferson was the only one studied.

Cypripedium is represented by five species.

C. candidum Muhl, has been reported from Steuben by E. Bradner, and also from Gibson and Posey by Dr. Schneck, who states that it was at one time very common in that locality, but is rapidly disappearing.

C. parviflorum Salisb., is reported from Lake and Noble in the north; Dearborn in the southeast; Gibson and Posey in the southwest. In Noble it is rare and grows in birch marshes. It was at one time common in Gibson and Posey, but is becoming rare.

C. pubescens Willd., grows in northern and central counties. It was, at one time, common in Franklin, but is becoming rare. Mr. Van Gorder states that it is very common in dry woods in Noble

C. spectabile Salisb., is another extreme northern species. It is found in Noble growing in moist, shady places of tamarack swamps and bogs. It is reported also from Steuben by E. Bradner.

C. acaule Ait., has been collected in Noble by W. B. Van Gorder whose specimen was examined. It is also reported from Lake.

Out of the thirty-seven species named in this paper twenty-seven have been verified by herbarium specimens. Most of the others doubtless occur in the State, as they have been reported by good authorities.

From these facts we find that the following species are found only in the region north of an imaginary line drawn east and west through Indianapolis:

Liparis Lœselii, Spiranthes latifolia, Goodyera repens, Arethusa bulbosa, Calopogon pulchellus, Pogonia ophioglossoides, Habenaria tridentata, H. virescens, H. bracteata, H. Hookeri, H. orbiculata, H. ciliaris, H. leucophæa, H. lacera, Cypripedium spectabile and C. acaule. Of these the following are confined exclusively to the northern tier of counties: Goodyera repens, Arethusa bulbosa, Habenaria tridentata, H. virescens and H. hyperborea.

The following are reported only in the region south of the above named line: Microstylis ophioglossoides, Liparis liliifolia, Corallorhiza innata, Habenaria fimbriata and H. peramœna. Habenaria fimbriata is confined exclusively to counties bordering on the Ohio river.

Habenaria virescens and Goodyera repens are reported only from Steuben County, and need verifying specimens to support the reference.

Three species, viz., Arethusa bulbosa, Habenaria tridentata and H. hyperborea, are reported exclusively from the western portion of the State, yet it is a noteworthy fact that all three come from Lake County, and are doubtless exclusively northern species. In all probability a careful study of the flora of the northeastern counties would show no division between the eastern and western species.

FIRST REPORT OF THE BIOLOGICAL STATION.

TURKEY LAKE* AS A UNIT OF ENVIRONMENT, AND THE VARIATION OF ITS INHABITANTS.

FIRST REPORT OF THE INDIANA UNIVERSITY BIOLOGICAL STATION. BY C. H. EIGENMANN.†

INTRODUCTORY.—At the last meeting of the Academy I outlined a plan for the future work of the zoölogical section of the biological survey of Indiana. It was, in brief, to study some lake as a unit of environment and the variation of its inhabitants. This plan has materialized, and I present this as the Biological Station's first report.

To select a suitable site I visited, in February, 1895, lakes Maxinkuckee, Eagle and Turkey. The lakes were frozen over, and I had a good long walk over Maxinkuckee and a sleigh ride over Turkey Lake. Turkey Lake seemed well suited for a starting point for the work in hand. In March I again visited this lake to look for a suitable laboratory and quarters. A laboratory was found in a large boat-house belonging to Mr. T. J. Vawter, the owner of Vawter Park. The boat-house is directly on the water's edge, in about 86° 18′ east longitude and 41° 23.5′ north latitude. In March the lake was still frozen over with but a narrow rim of free water near the shore. When I again visited the lake, to make the final arrangements, on the 30th of May, and captured snakes, turtles, frogs, and two species of spawning fishes, all within a hundred feet of the laboratory door, I was convinced that no mistake had been made in the selection of a locality. Deep water near the laboratory, a spring at the laboratory door, the situation of the laboratory nearly equidistant from either end of the lake, high land all about the laboratory, the nearness of such large bodies of water as Lake Tippecanoe of another river system, and a large number of smaller lakelets within a mile of Turkey Lake, all contributed to make the location selected as near perfect as could be expected

*The only recorded name of this lake seem to be Turkey. It appears so in the government surveys of 1838, and on all the maps published since that time. I am told that it received that name from the fancied resemblance of the general outline of the lake to a Thanksgiving turkey. During the last few years the lake has been known to those personally acquainted with it as Lake Wawasee, and there seems to be a laudable ambition that this latter name should supplant the homlier, but more significant, name of Turkey. The lower lake is locally known as Syracuse Lake.

The following letter was received from the Director of the Bureau of American Ethnology: In response to your letter of December 6th last, I beg leave to inform you that the word "wa-wá-seç," "wa-wá-si" or "wa-wá-sing," signifies "at the bend of a river."

Yours with respect, J. W. POWELL.

†Contributions from the Zoölogical Laboratory of the Indiana University, No. 14.

A twelve-room cottage was rented, in which fifteen of the members of the Station besides my family were quartered. While a summer cottage, thus peopled, is not a good place for consecutive thinking, this experience will also be remembered with pleasure. Most of the students rented a large dining tent and hired a cook. Others tented and boarded themselves. Their expenses ranged from $1.25 to $3 per week.

The laboratory was open from June 25 to September 1.

ACKNOWLEDGMENTS.—Mr. T. J. Vawter, besides placing the boat house at our disposal, gave us camping ground just back of the laboratory, and assisted us in various ways, both in fitting up the Station and during the entire summer.

I am under many obligations to the officers of the Baltimore & Ohio, the Vandalia and the Michigan Division of the Big Four for transportation over their lines leading to Vawter Park, and for other favors.

During our stay at Tippecanoe Mr. W. S. Standish assisted us very materially. He took the whole party on a tour of general inspection about the lake from end to end, and placed himself and his st amer at our disposal during our entire stay.

The Pottawatomie Club granted us the use of their reception room, where some of the lectures were delivered.

Professors Birge, Kellicott and Call have prepared accounts of material collected during the summer.

I must especially thank Dr. J. C. Arthur, Dr. G. Baur and Geologist Willis Blatchley, who visited the Station to deliver lectures before the members.

Lastly, I am indebted to Mr. J. P. Dolan, superintendent of the Syracuse schools. He first directly, and through Mr. Eli Lilly, of Indianapolis, called my attention to Turkey Lake, met me at Warsaw, and guided me to the lake and over and around it on my first visit. During the summer he furnished the Station with a splendid row-boat, and by his knowledge of the lake and its surroundings and personal acquaintance with the natives contributed much to the success of the undertaking.

EQUIPMENT.—The equipment of the Station consisted of a room 18x30 feet, with six windows on a side. In this space the twenty-two members of the Station were provided with tables. Continuous with this available laboratory space was a space 18x20, opening by very wide doors to the lake front. This space was utilized for storing apparatus. The apparatus, nearly all furnished by the Indiana University, was as follows: Compound microscopes (Zeiss), 21; dissecting microscopes, 3; microtome, 1; dredge, 1; plankton net, 1; Birge net, 1; dipnets; reagents, about 200 bottles; working library, about 200 volumes; Wilder's protected thermometer, 1; lamps, glassware, etc., the usual equipment of a laboratory

table; two boats; one sounding machine. The plankton net and sounding apparatus and the method of using them may be described here.

PLANKTON NET.—An idea of our plankton apparatus and its modus operandi can be gathered from one of the illustrations. The sounding boat was fitted in the stern with a swinging derrick. Through the end of this was attached a pulley, through which the rope supporting the net passed. The derrick was high enough to allow the net to swing clear of the sides of the boat, so that when a haul had been made, the net could be swung forward over a tray of tubes, ready to receive the condensed plankton. The depth through which hauls were made could be ascertained either by means of the sounding apparatus or by the direct measurement of the plankton rope. The plankton net was built essentially as devised by Hensen and Apstein, except that the straining net of No. 20 silk bolting cloth, Dufour's, was permanently attached to the truncated cone of canvas. The bucket which receives the plankton was from necessity greatly simplified, but as no measurements were made with it, and further improvement, both in efficiency and simplicity, have been devised, I will describe this instrument as it will be made for next summer.

The diameter of the bucket will be made one and one-half inches. Its bottom will be of a sheet of brass or copper, hammered so that it will be slightly concave or cup-shaped. A hole will be punched from the inside and provided with a nipple soldered on the outside. The sides of the bucket will be made of one piece of wire net of the same caliber as the No. 20 bolting cloth of Dufour.* The upper part of the bucket will consist of a flat brass or copper ring soldered to the wire sides, and provided with openings through which the binding screws, fastening the whole bucket to the net, may pass. Three legs of narrow strips of copper passing from the upper ring along the sides of the bucket, being also fastened to the bottom, will give rigidity to the sides and form a support for the bucket when it is being emptied. To the nipple at the bottom of the bucket will be attached a short rubber tube. The opening in the bottom will be closed with a tight-fitting rubber stopper, manipulated from above by a glass rod passing through its middle. The whole cost of the bucket need not exceed $3.50. The estimate received on one of Hensen's pattern was $25.

* Only part of the sides were made of the wire netting during the past summer. A piece of new bolting cloth was found to have 83 per cent. of its surface solid, 17 per cent. being open for the passage of water. The wire cloth used during the past summer had 77 per cent. of its surface solid, 23 per cent. being open for the passage of water. Repeated trials of forcing water thick with plankton through the bolting cloth and through the wire showed that the wire was under such conditions a more effective strainer than the cloth.

Sounding Apparatus and Method of Using it.—A flat-bottomed boat capable of running into shore at all points was manned by three persons. One who was an expert and steady oarsman at the oars, one in the stern to take notes and steer, and one in the bow to make the soundings. The sounding apparatus consisted of a wheel two inches wide with a circumference at the bottom of a flat marginal groove of one foot ten inches. (It had been ordered with a circumference of two feet.) On the drum was wound 175 feet of fine annealed wire. This, when wound, formed less than two layers over all parts of the drum. The weight consisted of a round pebble as large as a fist and was tied in a piece of cheese cloth. This was a very simple and efficient piece of apparatus. The weight, if lost, could easily be replaced by one of several others carried along, and the wire was found sufficient for the whole summer's work. The original cost plus the cost incident to its operation did not exceed $1.50. The wheel was provided with a crank and being of a definite circumference the depth was measured by the number of turns it took to raise the weight from the bottom to the surface. This apparatus would be efficient in any lake of moderate depth. To run a line of soundings the bearing to the objective point on the distant shore were taken from the starting point with a compass. The oarsman pulled thirty strokes, backed water and held the boat. A sounding was made in the bow and the depth recorded by the man in the stern. It was found that with the boat always used for the purpose, manned as above in calm weather, when all the sounding was done, 30 strokes moved the boat 300 feet. This method proved entirely satisfactory in short lines a mile and a half in length. In long lines it proved unsatisfactory.

Additions to the Equipment. A new laboratory 18x55 feet, two stories high, will be ready for occupation by June 1 of 1896.

A partial description of new apparatus devised for next summer's work may be given.

One flat-bottomed boat similar to sounding boat, 12 feet, 2 oars.

One flat-bottomed boat 15 feet, four oars. Plankton apparatus.

Three glass-bottomed galvanized iron boats about 12 inches in diameter to explore bottom.

One galvanized iron tube 2 inches by 20 feet, glass ends and funnels for filling or emptying, to determine color of water.

Automatic recording apparatus to observe seiches.

Plan of Work.—It must be understood that the undertaking was quite expensive both in time and in money. The Indiana University endorsed the plans and lent apparatus from the zoölogical laboratory with the provision that

the Station be of no expense to the University. At the end of the season the University paid for some of the apparatus specially designed for the Station, which thus became the permanent property of the University. In order to defray expenses, a series of courses in elementary and advanced instruction were offered and given. Each one of the advanced students and the instructors took charge of some particular work of the survey. The preliminary reports of some of these, form part of this first report. The work was distributed as follows:

C. H. Eigenmann, Director.

W. J. Moenkhaus, Variations in Etheostoma.

F. M. Chamberlain, Variations in Lepomis.

J. H. Voris, Variations in Pimephales

D. C. Ridgley, Physical Survey and Variations in Micropterus.

Bessie C. Ridgley, Variations in Labidesthes.

Thom. Large, Physical Survey and Variations in Fundulus.

Chancy Juday, Physical Survey and Planktonist.

Curtis Atkinson, Variations in Batrachians.

H. G. Reddick, Variations in Reptiles.

O. M. Meincke, Botanist.

J. P. Dolan, Meteorologist.

The work of but few has progressed far enough to justify even "forläufige" notices. We have but just begun our work, and the Station will remain at least three years longer at the same place. Excursions were made to lakes Tippecanoe, Webster, and Shoe in the Mississippi basins.

While much of this report is taken up with the physical features of the lake, and the enumeration of the inhabitants, it must be borne in mind that the physical studies are merely a means to an end. That however interesting in themselves, to us they are only interesting as far as they form part of the environment of the highest creatures making the lake their permanent home. It may even be that some of the things considered or to be considered, form in reality no part of the environment of the vertebrates, *i. e.*, that they in no way affect them, but this is a matter that must be determined, and for the present we must consider as many things as *may* influence them. The things probably most directly influencing the higher forms to be found in a lake are light, temperature and food. The last item is again conditioned as the highest forms are, so that nothing short of a complete understanding of the conditions will be sufficient. A lake seemed to me the ideal place because here the changes due to light, temperature, change of water or surface are reduced to the minimum to be found in this latitude. A

small lake is better than a large lake, because the unknown elements can be reduced to a smaller number.

We have attempted to collect specimens of the higher creatures in such numbers and sizes, that had we collected all the specimens in the lake, our results would not be different. How far we have succeeded in this remains to be seen.

The main object of the Station is the study of the variation of the non-migratory inhabitants. I may be permitted to quote here the plan as stated in the circular issued by the Station last spring.

The main object of the Station will be the study of variation. For this purpose a small lake will present a limited, well circumscribed locality, within which the difference of environmental influences will be reduced to a minimum. The study will consist in the determination of the extent of variation in the non-migratory vertebrates, the kind of variation, whether continuous or discontinuous, the quantitative variation, and the direction of variation. In this way it is hoped to survey a base line which can be utilized in studying the variation of the same species throughout their distribution. This study should be carried on for a series of years, or at least be repeated at definite intervals to determine the annual or periodic variation from the mean. A comparison of this variation in the same animals in other similarly limited and well circumscribed areas, and the correlation of the variation of a number of species in these areas will demonstrate the influence of the changed environment, and will be a simple, inexpensive substitute for much expensive experimental work.

For this work the situation of Lake Wawasee, surrounded as it is by other lakes, some of them belonging to other river basins will be admirably adapted.

In connection with this study of the developed forms, the variation in the development itself will receive attention. For instance the variation in segmentation, the frequency of such variation, and the relation of such variation in the development to the variation in the adult, and the mechanical causes affecting variation.

This plan will be modified as our knowledge grows and our experiences dictate.

PART I. THE LAKE AS A UNIT OF ENVIRONMENT.

INTRODUCTORY. – A lake is a depression in the ground filled with water more or less stagnant.

A glance at a good map of North America will show the following peculiarities in the distribution of lakes:

I. A large number of lakes are found in Florida.

II. A host of them are distributed in northern United States and Canada, including the greatest collection of fresh waters on the globe.

III. A good number in the Sierra Nevada and the Rocky Mountains.

The remainder of the country from the southern boundary of Georgia to the northern boundary of Pennsylvania west to the Rockies is practically free from lakes, except

IV. along either side of the lower Mississippi and Red Rivers.

These four groups of lakes are due to four different methods of lake formation, but all four are indicative of the fact that the lake-rich areas have undergone recent change.

The first series is due to the comparatively recent elevation of an irregular oçean floor. The second series is due to the action of ice in the irregular gouging and irregular dumping of debris. These are all of recent date, probably none of them being over 10,000 years old. The third series is due to the exigencies of mountain formations, including in this plication and plication hollows, craters and lava flows and the settling of small areas. The fourth is due to the change of channel on the part of the Mississippi and to the debris brought down by the Red River which it has deposited at the mouths of its tributaries.*

Of course the lakes of one of these regions need not be all of the same origin. Small lakelets around Lake Tahoe in the Sierra Nevada are certainly due to the gouging action of glaciers coming from a steep incline onto a comparatively level plain. Generally speaking, mountain regions, unless, as in the case of the Appalachian, they have outgrown their lake stage, contain lakes of the greatest diversity of origin.

Lakes are of interest to the geologist to determine the particular way in which a general cause has been modified to produce a particular effect at any particular lake; to the physicist to account for the various colors, temperatures, pressures, reflections, refractions, etc.; to the chemist to determine the degree of concentration of minerals and gases in solution; they are of interest to the naturalist to determine the organic inhabitants, their quantity and kind and their life histories; to the œcologist and evolutionist to determine the geological, physical and chemical characters in their effect on the organic inhabitants and these on each other.

Lakes may therefore be studied for other than purely economic interests, such as water supplies and highways for commerce or location of summer resorts.

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*The facts for the foregoing have largely been drawn from Russell's American Lakes. Ginn & Co., 1895.

Orientation.—A hight of land (morain) extends from the northeastern corner of Indiana directly southwest to south of Albion in Noble County, and from here westward between Turkey Lake and Tippecanoe Lake, then northwest through Nappanee in Elkhart County to near South Bend. In its range from the northeastern corner to south of Albion this ridge separates the Lake Michigan from the Lake Erie basin. West of this it separates Lake Michigan basin from the Ohio basin, and still farther west from the Mississippi basin proper. In the eastern half of Indiana this ridge is exceedingly rich in lakes. Most of these lie on the northern side of the divide, but about the headwaters of the Tippecanoe and Blue rivers many are also found on the south side of the divide. A glance at the map leaves the impression that this region is low and swampy, while in reality this whole region forms one of the highlands of Indiana, a considerable part being over 1,000 feet high.

Turkey Lake is the most western lake of this series lying north of the divide.

It lies in Turkey Creek Township, in the northeastern corner of Kosciusko County. South of the ridge separating the Mississippi and St. Lawrence basins at this point lie Webster and Tippecanoe lakes, and south of these the Barber lakes and Shoe Lake. Between the crest of the ridge and Turkey Lake the country is pitted and grooved. Many of the pits are filled with water, forming ponds of various sizes. One of these has recently been drained. Many more lakelets are found about the head of Turkey Lake, but the topography of this region will be dealt with in one of the following reports. This whole region gives one the impression that it has changed but little since the ice left it.

General Features.—The lake has a general trend from southeast to northwest. It is divided by a wide stretch of very shallow water, which is fast being reclaimed by various water plants. A deeper channel extends through this swampy region, connecting the upper and lower portions.

The greatest length from the head of Turkey Lake to the end of Syracuse Lake is five and one-half miles. The width, measured at right angles to such a line, rarely exceeds a mile. The greatest width is just east of Ogden Point, where it measures one and a half miles. The length of Turkey Lake from Mineral Point to Conkling Hill is about four miles. The total shore line is between twenty and twenty-one miles.

The excellent map prepared by Messrs. Juday and Ridgley, based as it is on numerous soundings, shows the lake bottom to be of the same rolling character as the surrounding region. A lowering of the surface of the lake ten feet would make the long stretch of territory between Syracuse and Turkey lakes dry land, and make the lake entirely landlocked.

The similarity of the lake bottom to the surrounding country, which seems to have been little changed by erosion, makes it quite certain that the lake basin is due to the irregular dumping in a terminal moraine, parts of it containing deeper kettle holes.

The lake was never much more extensive than now. There are evidences that the surface was a few feet higher. These will be considered in a later report. The lake is surrounded by extensive swamps on the east, north, and west; these would practically all be covered by water should the surface of the lake be raised five feet. The hydrographic basin is so small that at present but seven inches of water are removed from the surface by outflow, while thirty are removed by evaporation. The lake having a surface of 5.6 square miles, an increase of this surface by $\frac{7}{30}$, or about one and a third square miles, would be sufficient to allow all the water coming into the lake to be lost by evaporation except in wet seasons. The surface of the lake, therefore, can not have been very much higher than at present if the present precipitation and evaporation have been constant since the ice left this region. The lake has been about six or seven feet lower, having been raised to its present height by the building of a dam across its outlet. The changes due to this dam and to the encroachment of plants will be considered in another report.

SIZE. - The total area now under water is 5.659722 square miles. This area was obtained by weighing a sheet of paper of uniform thickness and of the shape of the whole area to be calculated, and comparing this weight with the weight of a square of the same paper covering a square mile. This method is much more expeditious than calculating such an irregular body as these lakes in the absence of a planimeter, and quite as exact. The same method was used in determining the areas below which there is a certain depth of water, with the following results:

Depth of Water.	Area in Square Miles.	Amount of Water in Cubic Miles.
1–10 feet	3.27777	.00310395
10–20 feet	.59027	.00167690
20–30 feet	.62500	.00314867
30–40 feet	.45833	.00303817
40–50 feet	.39583	.00337165
50–60 feet	.22918	.00231162
60–70 feet	.0694	.00082026
	5.64576	.0174712
Error to be distributed	.1396	
	5.65972	

Forel (Faune profonde des lacs Suisses, p. 5) proposed to estimate the volume of a lake by comparing it with a cone whose height is the maximum depth, and whose base is the surface of the lake. Estimated in this way he found the cone gave but .67 of the actual volume of Lake Geneva. A similar estimate for Turkey Lake will give us .024654 cubic miles, or considerably more than the actual value. The average depth obtained by dividing the cubic contents by the surface gives us 16.6 feet. All these measurements were made during the summer of 1895 when the lake was below the average height, so that 17 feet will probably be nearer the average depth. It will be found that by another method Mr. Ridgley obtained 21 feet as the average depth.

Over half the area contains water less than 10 feet deep. A reduction of thirty feet below the present level would reduce the lake to a Y-shaped figure extending nearly from end to end of the present lake. One of the horns of the Y would extend to Crow's Bay, the other to Mineral Point. The base of the figure would lie to the west of Black Stump Point. Between the horns of the Y we should have a peninsula continuous with Morrison's Island, which is the last of a series of islands left in the lake. During the ancient history of the lake the land about Buttermilk Point was an island, and ridges of land east and west of this formed the islands. One of these is seen in the illustration. The detailed description of the hydrography of the lake will be given in the map and Mr. R dgley's report.

Relation of Water to Outflow and Evaporation.—Without any addition to the water of the lake the quantity now in the lake would be sufficient to supply the present outlet for 26 years.[*]

In other words, every cubic foot of water entering the lake will remain in it on an average of twenty-six years, unless removed by evaporation. Ridgley estimates that the inflow from springs equals the outflow, yet the lake was observed to fall on an average of one-quarter inch per day, rising of course during rains. That the outflow will not account for the fall of the lake is sufficiently shown by the fact that the calculated fall due to the outflow is but .0016 inches per day. (See Ridgley's report). The remainder of the fall must be due to evaporation and seepage, very largely to the former. Attempts were made to estimate the amount of evaporation from the surface, but they proved failures. It is self-evident that simply exposing water in an open dish will not answer the purpose of estimating the amount of evaporation in the lake for the reason that water in a shallow dish is heated to very different degrees from the water of the lake. An

[*]Based on Ridgley's and Juday's estimate of the outflow, and my estimate of the lake's contents.

apparatus which promised to measure the evaporation accurately and at the same time do several other things was devised, but it proved a failure because it could not be well protected in rough weather and still maintain natural conditions. The apparatus which we hope we shall be able to perfect is as follows:

A glass jar 9 inches in diameter and 12 inches high with a small hole near the bottom and open at the top is sunk into the lake to within two inches of its top. When the water in the jar has reached the level of the lake water a tight rubber stopper is inserted in the small opening from without. The column of water in such a jar would be as near as possible under the same conditions as the surrounding water, and the fall of the water in the jar, plus the amount of rainfall for the period, would very closely approximate the amount of evaporation. This apparatus would also enable one to get at the amount of water received from springs and other sources aside from rain falling directly into the lake. The amount of reduction due to outflow from the lake can readily be calculated by observing the outlet. Mr. Ridgley has estimated it at .0017 inches per day. If at the end of thirty days there was a difference between the water in the jar and the water in the lake, less the calculated reduction of the lake due to outflow, the difference would represent the inflow from springs and other tributaries during thirty days.

The lake is frozen over about four months in a year. During the remaining eight months evaporation is going on at a maximum rate of one-fourth inch per day and a minimum of 0. Taking one-eighth inch per day as the average, we obtain about thirty inches as the amount of the annual evaporation. At this rate the lake, if without income, would become dry in twenty-eight years. Four years would reduce the lake to half its present size.

Outflow and evaporation operating together would reduce the level at the following rate:

Time in Years.	Reduction by Outflow.	Reduction by Evaporation.	Total Reduction.
3	1 ft. 9 in.	7 ft. 6 in.	9 ft. 3 in.
3	4	7 6	11 6
2	3 2	5	8 2
2	4 8	5	9 8
2	6 8	5	11 8
1	5 2	2 6	7 6
1 about	17 7	2 6	10 1
14	33 2	35	68

These figures do not claim any great degree of accuracy; they simply help to form an estimate of the length of time it would take both the outflow and evaporation together to empty the lake. But while it would take both the outflow and the evaporation fourteen years to empty the lake, one-fourteenth does not express the per cent. of the water of the lake changed annually under present conditions. Since the vertical reduction is the same whether the surface is large or small, it is evident that a much larger amount would be evaporated while the surface is large. In reality, if a bulk were to be taken from the lake equal to the outflow, plus the evaporation over the present area, about six years would be sufficient to empty the lake, or, to put it in other words, during average years every cubic foot of water entering the lake remains on an average six years. During very wet seasons the amount of loss may reach a much larger proportion of the whole contents.

Constancy of Turkey Lake as a Unit of Environment.—From the preceding chapter it must be evident that the conditions in the lake, from month to month and from year to year are but little changed, that the conditions, as far as the water is concerned, are remarkably constant, especially if we compare these conditions to those obtaining in the lower courses of such rivers as the Wabash or the Illinois.

In the early part of this century a dam was built across the mouth of the outlet forming an effective barrier to the ingress of fishes from below. The lakes being at the headwaters, nothing has entered it from above. A few forms were planted in recent years by Col. Lilly of Indianapolis.

The level of the lake was changed by the building of the dam, and as late as 1840 trees were standing in water six to seven feet deep. Many of the stumps still remain. Their location and the effect of the dam upon the lake will be discussed elsewhere.

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A Preliminary Report on the Physical Features of Turkey Lake. By D. C. Ridgley.*

ACKNOWLEDGMENTS.

Most of the data on which this preliminary report is based were collected during the summer of 1895 at the Indiana University Biological Station at Vawter Park, Kosciusko County, Indiana, under the direction of Dr. Carl H. Eigenmann. I wish to acknowledge the aid of his valuable suggestions, both in the collection of the data and the preparation of the report. I wish to acknowledge also the

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* Contributions from the Zoölogical Laboratory of the Indiana University, No. 15a.

PLATE I.

No. 1.

Indiana University Biological Station.

No. 2.

Interior of the Laboratory.

PLATE II.

No 3.

Vawter Park Hotel from the Laboratory.

No 4.

Black Stump Point from the Laboratory. Plankton Boat

PLATE III.

No. 5.

Looking Toward Ogden Point from the Laboratory. Plankton Boat in Forewater

No. 6.

Ogden Point from Near the Pottawatomie Club House.

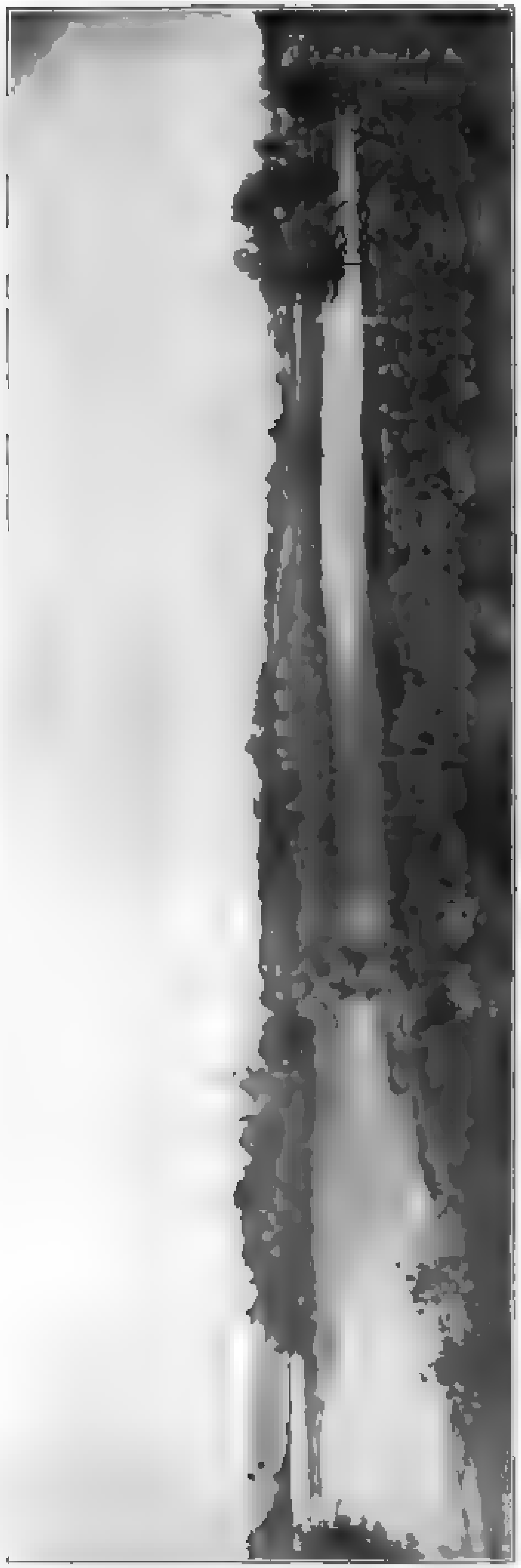
PLATE IV.

No. 7.

STUDENTS' CAMP IN VAWTER PARK.

PLATE V.

No. 8.



TURKEY LAKE.
HARTZELL'S LAKE, II.
HARTZELL'S LAKE, III.

OLD ISLAND

GAYS' LAKE.
HOOPER'S LAKE.
HARTZELL'S LAKE, I.

General View from Moraine at Head of Turkey Lake.

PLATE VI.

No 9.

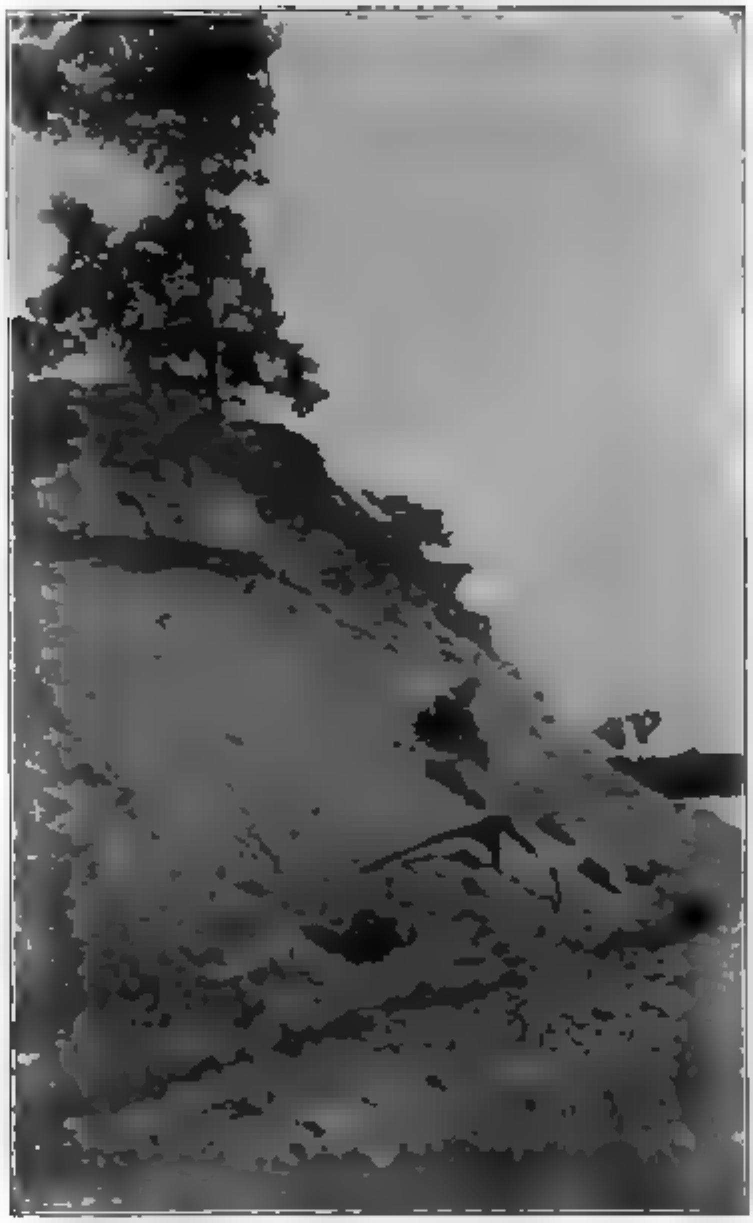
West Beach of Morrison's Island.

No. 10.

Crow's Bay Showing Ice Beaches.

PLATE VII.

No. 11.



Cedar Point.

No. 12

Beach West of Cedar Point.

PLATE VIII.

No. 13.

IN THE CHANNEL BETWEEN TURKEY AND SYRACUSE LAKES.

No. 14.

AT THE HEAD OF SYRACUSE LAKE.

assistance of Mr. Chauncey Juday, Mr. Thomas Large and others in taking the soundings of the lake; of Mr. Juday, in making a survey of the shore and for copies of the accompanying map with which he has furnished me and from which the report on the topography of the bottom is largely drawn; of Mr. J. P. Dolan for records of daily observations of lake phenomena and for the history of the lake in years past; of the officials of the Baltimore & Ohio Railroad who furnished data with reference to elevations and whose generosity has made it possible for me to make frequent visits to the lake during the winter.

GENERAL FEATURES OF THE LAKE.

Turkey Lake is made up of two parts, connected by a channel. The channel is three-quarters of a mile in length and from one hundred feet to a half mile in width. Its depth varies from one to five feet. The part of the Lake north of the channel is known as Syracuse Lake. It includes an area of three-quarters of a square mile, which is approximately one-eighth of the area of the entire Lake. The larger part of the Lake, to the south and east of the channel, may be known as the main lake.

The general direction of the lake is from southeast to northwest. Its greatest length is five and a half miles, and its greatest width at a right angle to its length is one and a half miles. The entire shore line is between twenty and twenty-one miles in length, and the area of the lake is a little more than five and a half square miles. No very prominent irregularities occur around Syracuse Lake, while in the main lake a number of evident indentations are to be found. The east end of the main lake is made up of three bays. Johnson's Bay, extending to the north, is one mile long and three-eighths of a mile wide. Ogden Point lies to the west of the entrance of this bay and Cedar Point to the east. The east end of the main lake is Crow's Bay, with Cedar Point on its north and Morrison's Island on its south. Jarrett's Bay extends to the southeast, with Morrison's Island to the east of its entrance and Clark's Point to the west. In the west end of the main lake is Conkling Bay, circular in form and with the surrounding marsh a half mile in diameter. It lies south of Conkling Hill. These are the most prominent indentations. Between the channel and Ogden Point, which are two and a quarter miles apart, the shore line curves gently northward three-quarters of a mile, forming Sunset Bay. Between Clark's Point and Black Stump Point, one and three-quarters miles to the northwest, the shore line bends southward one-third of a mile.

The following places are located for convenience in referring to different parts of the shore line and lake: The town of Syracuse lies on the west side of Syracuse Lake near Turkey Creek, the outlet of the lake. Pickwick Park is on the north shore of the main lake a half mile east of the channel. Eppert's is 1,000 feet east of Pickwick Park, and nearly a half mile further east is Jones' Landing. Three-fourths of a mile east of Jones' Landing is Wawasee. Jarrett's Landing is at the middle of the southern extremity of Jarrett's Bay. Vawter Park is a half mile west of Clark's Point and directly south of Wawasee. The laboratory of the Indiana University Biological Station is located on the shore of the lake near the west end of Vawter Park.

TOPOGRAPHY OF THE BOTTOM.

The data from which the topography of the bottom has been determined consist of numerous soundings taken throughout the lake between June 29 and August 21, 1895. The water was very low during this period. For our purpose we may consider all soundings taken when the lake had the level of July 6, 1895. This level has been marked and is used for a bench line from which to read the fluctuations in level On August 21 the lake had receded 5 inches from this level. Soundings were taken along 28 lines in the main lake and 4 lines in Syracuse Lake. These soundings were taken about 300 feet apart along all lines. Where water deeper than 60 feet was found, numerous soundings were made to determine the extent of such areas. Below is given the number and location of each line along which soundings were taken, except No. 3 and No. 9 in the main lake, neither of which was used in drawing contour lines or in computing average depth.

IN MAIN LAKE.

No. of Line.	Location.
1	From Biological Station to Ogden Point, North 37° East.
2	From Ogden Point to east end of Crow's Bay, South 53° East.
4	From Biological Station to Wawasee, North.
5	From Wawasee to Black Stump Point, South 52° West.
6	From Biological Station to Cedar Point, North 64° East.
7	From Cedar Point to Morrison's Island, South.
8	From Morrison's Island to northeast corner of Crow's Bay, North 8° East.
10	From south end of Jarrett's Bay to mouth of Bay, North 7° West.
11	From east margin of Ogden Point to north end of Johnson's Bay, North 1° West.
12	From north end of Johnson's Bay to mouth of Bay, South 10° East.
13	From east side of Ogden Point across Johnson's Bay, North 60° East.
14	From middle of east side of Johnson's Bay, across the Bay, North 79° West.
15	From Clark's Point to Morrison's Island, East.
16	From mouth of Turkey Creek across Jarrett's Bay, West.
17	From a point ⅜ of a mile west of Biological Station across the lake, North.
18	From Clark's Point to east side of Ogden Point, North 5½° East.
19	From point a half mile east of Biological Station, North.
20	From Ogden Point to Black Stump Point, North 83° West.
21	From west side of Jarrett's Bay to Mineral Point, East.
22	From Clark's Point to east side of Johnson's Bay, North 30° East.
23	From north end of No. 22 to Ogden Point, South 85° West,
24	From point one-half mile west of Wawasee across lake, South.
25	From Black Stump Point, North.
26	From Eppert's South.
27	One-quarter of a mile west of No. 26 and parallel with it.
28	One-quarter of a mile west of No. 27 and parallel with it.

IN SYRACUSE LAKE.

No. of Line.	Location.
1	From middle of east end of Syracuse Lake, South 80° West.
2	From point 700 feet southeast of west extremity of Lake, North 70° East.
3	From a point on north shore one-half mile east of west extremity of lake, South 10° West.
4	From west extremity of lake, South 80° East.

In the accompanying map, constructed by Mr. Juday, the hypothetical contour lines of the bottom of the lake were drawn from the soundings along the above mentioned lines, and numerous other soundings taken to determine the extent of certain depths of water. The contour lines indicate intervals of ten feet

in depth. From the same data were constructed ten vertical sections of the bottom. In constructing the vertical sections a base line was drawn from Pickwick Park to Mineral Point, and seven of the vertical sections, from "A" to "G" inclusive, were made at right angles to this line at intervals varying from one-quarter of a mile to two-thirds of a mile. Vertical section "H" is a short distance east of No. 18, "I" is along No. 4, and "J" along No. 25 of the lines of soundings in the main lake. The remarks on the topography of the bottom are drawn largely from a study of these contour lines and vertical sections.

The average depth of the lake, found by taking the average for the soundings at regular intervals of 300 feet along the lines of soundings is 21 feet 6 inches in the main lake, 13 feet 6 inches in Syracuse Lake, and 20 feet 5 inches for the entire lake. By a different method, as explained in his report, Dr. Eigenmann has computed the average depth at a little more than 17 feet. The maximum depth found in the main lake is 68 feet 7 inches, one-quarter of a mile from the southern extremity of Jarrett's Bay; 1,000 feet northeast of the Biological Station a depth of 66 feet 5 inches was found; three-quarters of a mile north and one-quarter of a mile west of the Station the water is 60 feet deep; and a half mile northwest of Black Stump Point it is 63 feet 3 inches deep. The deepest water found by us in Syracuse Lake is 28 feet 10 inches. A depth of 35 feet is recorded for this lake in the State Geologist's Report for 1875.

An examination of the contour lines of the map shows that if we consider water having a depth of 30 feet or more as deep water, we have in the main lake four areas of deep water varying greatly in size, and connected with each other by channels.

In Crow's Bay the greatest depth found was 49 feet 9 inches. These waters enter the main body of the lake through a channel deeper than 30 feet, and 200 feet wide at its narrowest point. This channel flows across the mouth of Johnson's Bay, meeting a short arm deeper than 30 feet from that bay, and comes within 600 feet of the southeast extremity of Ogden Point. This channel continues less than 400 feet wide to a point two-thirds of a mile west of Ogden Point where it joins the channel deeper than 30 feet from Jarrett's Bay. The deepest water in Jarrett's Bay is 68 feet 7 inches, and the area deeper than 30 feet is one-fourth of a mile wide, extending north beyond the mouth of the bay and to within 700 feet of its southern shore. This 30-foot depth joins the main body of the lake a half mile north of Clark's Point where the channel 30 feet deep is only 100 feet wide. Turning to the west, 1,000 feet northeast of the Biological Station this channel deepens to 66 feet 5 inches, and widens to a half mile directly north of the Station. Here it meets the narrow channel 30 feet deep from Crow's Bay.

The two channels merge into one and form an area of water from 30 feet to 66 feet in depth, one mile in length and with a maximum width of three-quarters of a mile. This area of deep water lies nearer the south shore, its center being one-third the distance from the south shore to the north shore. Near Black Stump Point the deep water narrows abruptly from the north, and 500 feet out from Black Stump Point its width is but 200 feet. West of Black Stump Point the deep water widens abruptly to the north to a width of one-quarter of a mile and deepens to 63 feet 3 inches. West of this the area of deep water narrows again and the water having a depth of 30 feet ends one-quarter of a mile southeast of the entrance to the channel between the main lake and Syracuse Lake.

Between the deep channels from Crow's Bay and Jarrett's Bay the area having a depth less than 30 feet is one and one-quarter miles long, 1,300 feet wide, and contains an area one mile long and 500 feet wide over which the water is less than 10 feet deep.

If the level of the lake were lowered 30 feet there would remain four bodies of water connected by channels from 100 feet to 200 feet wide and less than 10 feet deep. These four bodies of water would be: (1) a small area in Crow's Bay with a maximum depth of 19 feet; (2) about one-half of Jarrett's Bay with a maximum depth of 38 feet; (3) the main body of the lake, its width decreased almost one-half, and its maximum depth being 36 feet; (4) a small area northwest of Black Stump Point with a maximum depth of 33 feet. Lower the level of the lake 10 feet more, that is, 40 feet below its present level and these four bodies of water would remain as separate lakes, the connecting channels now being dry.

Great changes in the shore line will take place if the level of the lake be lowered to a much less extent. By observing the map it will be seen that a lowering of the level of the lake to the amount of 10 feet would move the shore line to the first contour line. This would leave one-half the bottom of Johnson's Bay dry land; it would move the shore line along Crow's and Jarrett's Bays from 400 feet to 1,000 feet into the lake. Clark's Point would extend 2,000 feet further north, and the distance between Clark's Point and Ogden Point would be reduced from 4,000 feet to 1,800 feet. The south shore line from Clark's to Conkling Bay would be moved northward distances varying from 250 feet at Iron Spring Point to 1,000 feet along the shore west of Black Stump Point. The north shore line from Ogden Point to the Channel would be moved southward from 900 feet to 2,000 feet, and at one place—between Jones' Landing and Black Stump Point—4,000 feet, reducing the width of the lake at this place from 1 mile to 500 feet. The Channel between the main lake and Syracuse Lake would be drained, and the greater part of Syracuse Lake would become dry land.

Judging from the contour of the land, the level of the lake has probably never been more than 5 feet below its present level.

TOPOGRAPHY OF THE SHORE.

The shore of 20 miles is about equally divided between dry shores and marshy shores. The shores of Syracuse Lake and of the west end of the main lake were not carefully surveyed, but accurate measurements and notes were taken of the shore line of the east end of the main lake from a point on the north shore three-eighths of a mile to the northwest of Wawasee, around the east end of the lake to a point directly south of the starting-point. These data were used in mapping a ten-foot elevation line around this part of the lake. For this reason the shores of the east end of the lake are treated more in detail than the others.

The dry shores are composed of sand and gravel. Some are less than 5 feet high, but more often they are abrupt bluffs from 10 to 30 feet high, or hills which ascend rapidly to a height of 40 feet. The west, north and northeast shores of Syracuse Lake are bluffs or hills. The east shore is marshy. The shore south of Turkey Creek, the outlet, is also marshy, and these marshes extend along both sides of the Channel between Syracuse Lake and the main lake. Pickwick Park is located on a gravelly shore less than 10 feet above the level of the lake. Between Pickwick Park and Eppert's is the Gordoniere Marsh extending northwest to the Channel. Pickwick Park and the land to the west of it is surrounded by the main lake, the Channel and the Gordoniere Marsh and is known as British Island. The shore between Eppert's and Jones' is mainly marsh. From Jones' one-quarter of a mile east the shore is a bluff from 10 feet to 15 feet high. From this point almost to Wawasee the land near the shore is at present a dry marsh. The bluff at Wawasee is 15 feet high and extends along the shore 1,700 feet. This bluff extends back from shore 500 feet where it joins the marsh which stretches along the shore to Ogden Island, and also to the east to Johnson's Bay. Ogden Island, which is surrounded by the lake only on the southwest side and on all other sides by marshes, extends a half mile to the northwest of Ogden Point and is from 300 feet to 1,000 feet wide. Its greater part is from 3 feet to 6 feet above the level of the lake. About one-half of that part of the island which touches the lake is a bluff from 10 feet to 18 feet high. The area higher than 10 feet is 1,100 feet long and from 175 feet to 400 feet wide. The marsh around Johnson's Bay is known as the Johnson Marsh. It skirts the southeast and east sides of Ogden Island, surrounds a piece of timbered land 700 feet in diameter

north of Ogden Island known as Oak Island, borders the bay on the north, sending off a broad marsh across the country to the northeast, and continuing along the east side of the bay with a width of a half mile, joins a narrow marsh extending to the southeast. On the east side of Johnson's Bay are two bluffs, one reaching a height of 23 feet and extending from Cedar Point northwest one-quarter of a mile along the shore and having 500 feet for its greatest width; the other is 1,000 feet further to the northwest, and is between 10 feet and 15 feet high, 700 feet long and 150 feet wide. Lying to the northeast of these bluffs and extending between them is an arm of the Johnson Marsh from 50 feet to 800 feet in width, which joins Crow's Bay just east of Cedar Point. From the northeast corner of Crow's Bay the bluffs extend south along the east end of the lake for a half mile. They are from 10 feet to 27 feet in height. The 10-foot elevation line then leaves the shore and extends almost south to Turkey Creek, leaving an area of well timbered dry land along the lake with an elevation of from 3 feet to 10 feet and attaining a width of 1,000 feet.

The land on both sides of Turkey Creek, the inlet of the lake, is marshy. Lying to the north of the mouth of the creek this marsh is 400 feet wide and extends one-quarter of a mile north along the lake. This marsh is separated from the marsh along the east margin of Morrison's Island by a shallow channel of water. The west side of Morrison's Island is a bluff reaching a height of 21 feet. From Turkey Creek to Buttermilk Point the shore is skirted with marsh from 200 feet to 400 feet wide. Mineral Point is 200 feet from the lake and ascends abruptly from the marsh to a height of 25 feet. A half mile south of Turkey Creek the lake is entered by Jarrett's Creek which is the outlet of a chain of small lakes lying southeast of Jarrett's Bay. This stream flows through a marsh 400 feet wide, and all the small lakes are bordered by marsh land. The marsh along the lake ends at Buttermilk Point, and for a quarter of a mile the shore is dry and sandy. The land along this shore is not a perpendicular bluff, but rises rapidly from the lake to the south and reaches a height of 40 feet at a distance of 400 feet from the shore. The west side of Jarrett's Bay is skirted by a marsh from 150 feet to 1,000 feet wide. West of the marsh is a bluff from 10 feet to 15 feet high continuous with the land south of the bluffs of Vawter Park. West from Clark's the south shore of the lake is a perpendicular bluff reaching a height of 29 feet in Vawter Park and extending west beyond the point where our survey of the summer ended. This bluff is cut by a ravine 50 feet wide at the Biological Laboratory and by a small stream entering the lake a quarter of a mile west of Vawter Park. The shore extending west to and around Black Stump Point is from 5 feet to 15 feet above the level of the lake. The high bluffs from Clark's Point to Black

Stump Point is by far the longest stretch of highland along the shore, being nearly two miles in length. Conkling Bay during the summer months contained an area of water about 300 feet in diameter and 20 feet deep, bordered by wide stretches of marsh containing a few small pools of very shallow water. To the north of Conkling Bay, Conkling Hill ascends rapidly to a height of 40 feet or more. This hill is conical in shape and slopes to the water on the south and east, and to marsh and lowland on the north and west.

It will be noticed that the perpendicular bluffs of the main lake face to the south at Jones' Landing; to the southwest at Wawasee, Ogden Island and Cedar Point; to the west along Crow's Bay and Morrison's Island; and to the north along Vawter Park. The high hills at Jarrett's and Conkling's are without precipitous shores. All of these bluffs are bordered by wide areas of shallow water, and it will be noticed that the 10-foot contour line of the bottom does not approach the shore much nearer than 400 feet, and is usually much further from shore. As a rule, the bluffs facing to the south and southwest have a much wider margin of shallow water than those facing to the west or north.

Wherever there is a long stretch of shore, bordered by marsh, there is no beach formed, but the muddy bottom of the lake merges into the mud of the marsh along the shore line. Along all the dry shores, and along the marshes of small extent lying between bluffs, the beach is composed of gravel and sand. This gives a gravelly or sandy beach around Syracuse Lake, except on the east and southwest; along the north shore of the main lake, from the Channel to Ogden Point; along the east shore of Johnson's Bay, from Cedar Point northwest to the extremity of the dry shores; from the northeast corner of Crow's Bay to a point east of the north end of Morrison's Island; along the south end of Jarrett's Bay; from Clark's Point along the south shore for a short distance beyond Black Stump Point. These beaches along the bluffs are formed by erosion and deposit along the base of the bluffs. The sandy and gravelly beaches along marshes are found where the adjoining bottom of the lake is composed of sand and gravel. These beaches have most probably been formed by the action of ice.

Around the main lake a number of beach formations of this kind are found. From Wawasee a half mile west the beach is composed of sand and gravel. It is about three feet above the water's level, and is higher than the land back of it. From the east end of the bluffs of Wawasee to the dry land of Ogden Island is a distance of a half mile, and the marsh along the shore is very little, if any, higher than the level of the lake. Between the marsh and lake is a beach composed of sand and gravel. This beach is two feet or more above the level of the water, and 30 feet wide. The beach along the bluff of Ogden Island is of the

usual formation, but this beach continues along the shore for one-fourth of a mile beyond the bluff as a very sandy beach a foot or more above the water's level and 50 feet wide; then the beach grows narrower and is on the level of the water, the sand becomes less plentiful, and the beach is composed of a small amount of coarse gravel and then merges into the marsh, where the shore line of Ogden Point turns north. The same formation is found running a short distance north of the bluffs on the east side of Johnson's Bay.

Between the two bluffs on the east side of Johnson's Bay is a beach 1,000 feet in length, with the lake on one side and a marsh containing pond lilies on the other. This beach is from 20 feet to 80 feet wide, 3 feet above the water's level, and composed of sand and coarse gravel. The margin of the beach further from the lake is the higher, and is covered with a growth of willows, cedar and other small trees. Along the lowlands of Crow's Bay is a broad beach composed of coarse gravel about three feet high and on a level with the land back of it. Along the south end of the west side of Morrison's Island, which is lowland, the beach is from 15 feet to 25 feet wide, three feet high, and composed of coarse gravel. The beaches along marshes and lowland are broader and higher, and contain much more material than those along bluffs.

The action of the ice is an important factor in the formation of these beaches. For the explanation of the action of ice on beaches as well as the formation of ice cracks, I am indebted to I. C. Russell's excellent book, "Lakes of North America." The lake freezes over and by expansion the ice is pushed up along the shore carrying sand, gravel and stones with it. Numerous ice cracks form during the winter and fill with water. This water freezes and pushes the ice still further up the shore carrying the beach forming material still higher. These ice cracks are very numerous and may be as much as three inches wide. The amount of lateral pressure brought to bear on the shores by this means is very great, and beach ridges are begun and added to each year. The action of the ice in forming beaches along marshes is very great, while along bluffs it is small. In the first case no great resistance is met with in expansion, and the material for building the beach will be carried up to the full extent of the expansion of the ice, while along the bluffs the ice crowds against the shore and is itself broken at every expansion. A recent ice formation is evident at the northwest end of the Gordoniere Marsh, between the marsh and the Channel. In 1891 this marsh was under water, but since that time the water of the lake has receded and left the marsh dry. Separating the marsh from the Channel is a ridge of earth more than one foot high running parallel with the water's edge. This ridge can be accounted

for by the action of the ice subsequent to the time when the marsh was left without water. Some of the most striking examples of ice action in the formation of beaches are found along the east side of Johnson's Bay; along Crow's Bay; at Morrison's Island, where two ice beaches, separated by a few feet, are now covered by trees; at Clark's Point, where an old beach extending as much as 200 feet from shore is found, and at Black Stump Point.

CHARACTER OF BOTTOM.

In the shallower parts of the lake the bottom is composed of sand, gravel, and small boulders, except along the low marshy shores, where it is composed of mud. At several places, both in Syracuse Lake and in the main lake, dredgings were taken at depths from 25 feet to 60 feet. Here the bottom was covered with a deposit of marl in which were found many diatoms and shells.

Further investigations will be carried on to determine more fully the character of bottom at different depths.

ICE.

For information concerning the freezing of the lake I am indebted to Mr. J. P. Dolan, who has given me the history of ice formations as he has observed them during years past, and he has furnished me with records of careful observations made since the first formation of ice in October, 1895. These observations, unless otherwise indicated, are for Syracuse Lake. Ice forms on the main lake at the same time, but it does not freeze entirely over so soon as Syracuse Lake.

The lake begins to freeze along the edge, except where strong springs enter near the margin. Information has been obtained concerning the influence of springs only at Crow's Bay and Vawter Park. Springs are numerous along Crow's Bay for a half mile and the water along the edge is kept open after the lake is frozen over, but I have not yet learned to what extent these springs influence the freezing of the edge of the lake in this locality. From Mr. Smith Vawter, who has observed the springs at Vawter Park for a number of years, I learned that the spring, which is near the margin of the lake and 200 feet east of the Biological Laboratory, keeps the edge of the lake open throughout the winter. If the weather is not severe, ice does not form for 25 feet along the shore, and from 12 feet to 15 feet from shore. In the severest weather the lake is kept open for 2 or 3 feet from the margin.

The ice spreads rapidly from the shore towards the center. The lake freezes over quite rapidly when the general temperature remains below 32° Fahrenheit

and there is no accompanying wind. All parts of the lake freeze, except where it is kept open by springs, but the last place to freeze is a narrow strip from 20 feet to 30 feet wide, extending from the north end of the Channel to Turkey Creek, the outlet of the lake. Ice sometimes forms to a thickness of 6 or 8 inches along the margins of this channel before it freezes over. This is due to a current along this narrow channel towards the outlet. The ice is always thinner here than elsewhere.

Accurate information could not be obtained concerning the exact date of freezing in 1894, but from Mr. Dolan's observations we can give an accurate account of ice-formation during the fall and winter of 1895.

The first ice of the season was observed on October 20. The temperature of the air at 7 A. M. was 28°. A thin layer of ice 4 or 5 feet wide had formed along the edge of the lake. It melted during the day. At 7 A. M. October 30, the temperature of the air was 26°, and about one-fourth of Syracuse Lake was frozen over. Not quite all the ice melted, but it all disappeared on the following day. At 7 A. M. November 2, the temperature of the air was 22°. The mill race was covered with ice three-eighths of an inch thick. Only the edge of the lake was frozen, as the wind blew during the night. On November 21, the temperature of the air at 7 A. M. was 13°, and ice had formed from shore to shore on Syracuse Lake; at 12 M. the ice was nearly all melted, and at 5 P. M. the lake was free of ice. This was the first date on which the ice extended entirely across the lake. On November 23, at 7 A. M., the temperature of the air was 30°. Ice had formed on the mill race, but no ice formed on the lake, owing to a slight wind. On November 27, the temperature of the air at 7 A. M. was 16°, and a wide belt of ice had formed around the lake, but it disappeared on the following day. On December 2, the night was clear and calm. There was no ice at 4 P. M., but at 7:30 P. M. a thin sheet of ice had formed and extended apparently from shore to shore. On December 3, Syracuse Lake was completely covered with ice. The temperature of the air during the day was 6° at 7 A. M., 16° at 12 M. and 12° at 5 P. M. On December 5, the ice was 2 inches thick near shore. On December 7, the ice near shore was $3\frac{3}{4}$ inches thick, and 500 feet out from shore $1\frac{1}{4}$ inches thick. I visited the main lake on December 7, and the ice appeared to extend over the entire lake. Warren Colwell had skated over the lake during the forenoon as far east as Ogden Point. The only place where he found the lake open was a space about 20 feet square, half way between Ogden Point and Black Stump Point. Three dozen ducks and mud-hens had congregated in this open space.

The increase and decrease in the thickness of the ice from December 9, to December 20, are shown in the following table. The measurements were taken 50 feet or more from shore.

Day of Month.	Thickness of Ice in Inches.	Temperature of Air at 5 p. m.	Condition of Weather.
9	4	18°	North wind; cloudy.
10	4½	26°	Wind, southwest to south.
11	5	36°	Snow and rain.
12	5¼	20°	Clear.
13	5½	24°	East wind; clear.
14	6¼	36°	Wind, south to southwest.
15	6¼	26°	Clear.
16	5½	39°	East wind.
17	5	46°	Southwest wind; rain.
18	4¼	52°	South wind; rain.
19	2¼	54°	South wind; rain.
20	0	52°	South wind.

On December 13, ice cutting for commercial purposes was begun, with the ice 5½ inches thick. Last winter no ice was cut until January 1, 1895, when the ice had reached a thickness of 6 inches. On December 15, the ice had reached a thickness of 6¼ inches, after which it grew thinner, owing to the rise in temperature and the heavy rains. By December 20, the ice had melted so that only slush ice remained. On the morning of December 21, this ice had drifted to the north and northeast parts of the lake and at 5 p. m. of the same day the ice had all melted.

Mr. Dolan has given me accurate information concerning the ice on the lake from January 1, 1895, to March 25, when the ice left the lake. On January 1 the ice was 6 inches thick and kept increasing in thickness for more than a month. The maximum thickness, observed by persons engaged in fishing through the ice, was noted in the early part of February and found to be from 24 inches to 28 inches. The greatest thickness is found where the ice has been kept clear of snow by the wind. In January and February the snow lay about nine inches on the level, but it was drifted in many places on the lake while other areas were without snow.

In the spring the ice sometimes wears into holes out in the open lake, and breaks up in the center of the lake first, the last ice to break being along the shores. This is the case when the ice goes off in cloudy weather and with heavy rains. Usually the ice begins to melt along the shore, with some holes further out. A heavy wind then breaks the ice and carries it ashore. For the past ten years the

ice has gone off with a west or southwest wind and has been piled up on the east or northeast shores.

In the spring of 1895, the ice went off the lake in an unusually short time. The lake had remained completely frozen over until March 24. During this day the ice began to melt along the shores. On the morning of March 25, the ice had melted to a distance of 20 feet from shore. At noon the ice had receded 400 feet from shore. A heavy west wind was blowing all day, and the cracking of the ice could be heard. At 3 p. m. the noise caused by the crushing of the ice became very loud and could be heard for a quarter of a mile. The ice was broken into huge cakes. The wind now began to lift the ice and drive it eastward. At 4 P. M. all the ice was piled along the east shore. The height to which the ice is piled depends on the character of the shore and the strength of the wind. The piles are not so high along a low marshy shore as along an inclined or abrupt shore. Occasionally a great sheet of ice is pushed up a smooth inclined surface 6 or 7 feet without breaking the ice to any great extent. An instance of this kind was observed by Mr. Dolan on the northeast shore of Syracuse Lake last March. No ice formed on the lake after March 25.

Ice cracks are very numerous from the time the ice forms entirely across the lake and has attained sufficient stability. They form before the ice has reached the thickness of one inch. When the first cracks formed in December the ice was so thin that it sagged slightly along the crack. The water came through the crack and spread over the surface of the ice sufficiently to melt the small amount of snow covering the ice, to a distance of 5 or 6 feet on each side of the crack.

The explanation of ice cracks as quoted from Gilbert by Russell in his "Lakes of North America" is so applicable to the case in hand that I reproduce the quotation here:

"The ice on the surface of a lake expands while forming, so as to crowd its edge against the shore. A further lowering of the temperature produces contraction, and this ordinarily results in the opening of vertical fissures. These admit the water from below, and, by the freezing of that water, are filled, so that when expansion follows a subsequent rise of temperature the ice can not assume its original position. It consequently increases its total area, and exerts a second thrust upon the shore. When the shore is abrupt, the ice itself yields, either by crushing at the margin or by the formation of anticlinals (upward folds) elsewhere; but if the shore is gently shelving, the margin of the ice is forced up the acclivity and carries with it any boulders or other loose material about which it may have frozen. A second lowering of temperature does not withdraw the protruded ice margin, but initiates other cracks and leads to a repetition of the

shoreward thrust. The process is repeated from time to time during the winter, but ceases with the melting of the ice in the spring."

The formation of these cracks is accompanied with noise, and, when the ice has reached the thickness of four or five inches, the noise resembles the distant booming of cannon. These cracks may be mere seams in the ice, or they may be several inches wide. On December 7, I measured a crack three-eighths of an inch wide in ice one and three-fourths inches thick. On December 9, Mr. Dolan measured one two and three-fourths inches wide in ice four inches thick. On the same day he counted eleven loud reports caused by the formation of ice cracks in five minutes. They form during all parts of the day and night. They cross the lake in every direction, and, while the cracks are slightly zig-zag, their general courses are in straight lines.

The ice is very clear and pure, especially out from the shore, where there is no vegetation near the surface. Is is used very largely for commercial purposes, the ice being cut from about one-fourth of the surface of Syracuse Lake each year.

INLET.

The only stream flowing into the lake and containing water throughout the year is Upper Turkey Creek, which enters the lake on the east side of Jarrett's Bay. During the summer months it was filled with an abundant growth of water vegetation, and was without any perceptible current. When the water is high the chain of small lakes lying to the southeast is drained into the large lake through Jarrett's Creek, entering Jarrett's Bay a half mile south of Turkey Creek. During the past summer no water entered the lake from this source. A small stream one-fourth of a mile west of Vawter Park, and another from the east side of Johnson's Bay, contribute water to the lake when the water is high, but not during the dry summer months. There are no springs around Syracuse Lake, but springs are found along the margin of the main lake wherever the shore rises fifteen feet or more and extends across the country as elevated territory. These springs usually enter the lake near high water mark. This gives springs along Crow's Bay, Mineral Point, the south and west sides of Jarrett's Bay, and along the south shore from Vawter Park one mile west. No springs are found along the bluffs at Jones', Wawasee, Cedar Point, Morrison's Island, or Conkling Hill, but in each case these highlands are narrow and surrounded by marsh or lowland. For a half mile along Crow's Bay the bluff is more than twenty feet high. All along the foo of the bluff the water percolates from the gravel, and at places it flows from quite strong springs. At Mineral Point there are a number

of strong springs. At Buttermilk Point and along the base of the bluffs west of Jarrett's Bay are a number of springs. The margin of the lake from Vawter Park one mile west is very springy, but the flow of water is not so strong as along Crow's Bay. The waters from all these springs show traces of iron more or less strongly.

OUTLET.

The waters of the lake flow into Lower Turkey Creek through which they enter the Elkhart River near Goshen, Indiana; then through the Elkhart and St. Joseph rivers they reach Lake Michigan.

Near the outlet of the lake the creek, during the summer, was about 20 feet wide and had an average depth of less than 6 inches. The volume of water discharged through the outlet was computed from measurements taken in the creek and the overflow of the mill race July 18, 1895. The outflow through the creek was 103 cubic feet, or 772½ gallons, per minute; through the mill race, 41 cubic feet, or 307½ gallons, per minute, making a total of 144 cubic feet, or 1,080 gallons, per minute. At the same time the volume of the creek a half mile below was computed at 137½ cubic feet, or 1,031 gallons, per minute.

By taking the outflow of the lake at 144 cubic feet per minute, finding the amount discharged in twenty-four hours, and computing the amount the level of the lake, with an area of 5½ square miles, would be lowered by such an outflow with no inflow, we find it to be .016 of an inch. At this rate it would require 62½ days to lower the lake one inch. In one year of 365 days, at the same rate, the level would be lowered 5.84 inches. The inflow, during the summer months, is almost entirely due to springs, and probably equals the outflow. The lowering of the level of the lake, during the summer months, seems to be due almost entirely to evaporation.

ELEVATION.

The elevation of the lake above the sea and above Lake Michigan is shown in the following list of stations and their respective elevations. The list of stations with their respective elevations above mean tide at Sandy Hook, New York, was furnished by the General Superintendent of the Baltimore & Ohio Railroad. The elevation of each station above Lake Michigan was found by subtracting 582 feet, the elevation of the surface of Lake Michigan above the sea, from the elevation of the station above the sea:

ELEVATIONS OF STATIONS ON BALTIMORE & OHIO RAILROAD FROM SOUTH CHICAGO, ILL., TO PATTON SIDING, IND., THE MOST EASTERN STATION IN INDIANA.

NAME OF STATION.	No. Miles from Grand Central Station, Chicago.	Elevat'n Above Mean Tide at Sandy Hook, New York, in Feet.	Eleva'n Above Lake Michigan, in Feet.
STATIONS IN ILLINOIS.			
South Chicago	19	593.0	11.0
Rock Island Junction		593.5	11.5
STATIONS IN INDIANA.			
Whitings		598.5	16.5
Edgemoor		596.5	14.5
Wilsons		604.5	22.5
Millers	37	617.0	35.0
Dock Siding		621.5	39.5
Willow Creek		640.3	58.3
McCools		640.5	58.5
Babcock		652.0	70.0
Woodville		687.8	105.8
Suman		748.6	166.6
Coburg		786.0	204.0
Alida	57	788.8	206.8
Wellsboro	64	760.0	178.0
Union Centre	71	718.5	136.5
Walkerton	79	716.0	134.0
Teegarden	85	800.7	218.7
La Paz		859.0	277.0
La Paz Junction	88	856.0	274.0
Bremen	96	819.0	237.0
Berlinton		853.0	271.0
Napanee	104	880.0	298.0
Milford Junction	112	840.2	258.2
Syracuse	116	869.2	287.2
Wawasee	120	882.2	300.2
Cromwell	125	935.2	353.2
Kimmell		923.2	341.2
York		901.6	319.6
Albion	135	926.2	344.2
Ripley		970.2	388.2
Avilla	145	961.2	379.2
Garrett	150	890.0	308.0
Auburn Junction	153	871.7	289.7
Inverness		864.2	282.2
St. Joe	163	812.2	230.2
Patton Siding		849.7	267.7

Syracuse is the station having most nearly the elevation of the surface of Turkey Lake. The mean level of the lake is about 5 feet below the station at Syracuse. This gives the lake an elevation of 864 feet above the sea, and 282 feet above the surface of Lake Michigan.

CHANGES IN LEVEL.

Changes in the level of the lake have been due to three causes: erosion, the dam which is built across Turkey Creek just below the outlet of the lake, and climatic conditions.

Old beach formations give evidence that the level of the lake was formerly 5 or 6 feet higher than at present. By erosion the channel at the outlet was cut 10 feet below this ancient level, and the dam has raised the level of the lake 5 feet to its present level.

The history of the dam as given by an old settler is as follows:

A small dam was built in 1828, to which additions were made in 1831. This dam washed out in 1833, and the present dam and mill race were begun in the same year. This raised the level of the lake so that timber stood in water 5 feet deep. Much of this timber remained uncut in 1840, and some was still standing as late as 1865.

The vertical distance between the level of the water in the creek below the dam and the top of the waste gate, December 7, 1895, was five feet. This would be the amount the dam, when in working order, would raise the level of the lake. The dam is not in use at present and a small portion has been removed, which allows the water to pass into the creek at a level 16 inches below the top of the waste gate. This present condition of the dam holds the water of the lake 3 feet 8 inches above the level of the water in the creek below.

The submerged stumps in many parts of the margin of the lake is the best evidence that the dam had the effect of increasing the area of the lake. These stumps stand at present in water from a few inches to two feet or three feet deep. Along the margin of Syracuse Lake the stumps are most abundant at the point of the lake extending furthest west, and on the east shore along the edge of the marsh. Turkey Creek, from the lake to the dam, is sixty feet wide, and only twenty feet along the middle is clear of stumps. This was the channel of the creek before the dam was built, and the stumps now standing in water are the remains of the timber which grew along the banks of the creek. On the north and south sides of Buck Island, at the south end of Syracuse Lake, areas of submerged stumps indicate that this island was formerly one hundred feet wider in

each direction. On the east side of the entrance of the main lake to the channel are many submerged stumps. Along Johnson's Bay much timber stood in water, especially on the east side of Ogden Point and on the east side of the bay just north of the bluffs. In these localities the stumps are very numerous, and among the largest in the lake. There are a few stumps along the marsh just east of Cedar Point. Others are found in the vicinity of Morrison's Island and go to indicate that this island, before the building of the dam, was a part of the mainland. It is so represented in the government survey of 1838. On the west side of Jarrett's Bay submerged stumps are numerous, especially along the southeast corner, where much small timber is still lying in the marsh at the margin of the lake, and at Clark's Point where many large stumps are found in the water. Submerged stumps are also found west of Black Stump Point. The elevation of the lake by the dam, not only increased its area but must have rendered much of the low level land in the vicinity of the lake marshy, which would have been tillable. It is claimed by persons living in the vicinity of the lake that the dam rendered four thousand acres of land untillable.

The fluctuations in the level of the lake are caused by climatic conditions, and vary with the inflow and outflow, rainfall and evaporation. In Mr. J. P. Dolan's report will be found the record of changes of level as observed during the past few months. Annual fluctuations are estimated to be about two and one-half feet. The level of the lake is usually highest about May 1, after the heavy spring rains, and lowest in August, although this year it kept lowering until November 2, owing to the very light rains up to that time. It was then ten and one-half inches lower than on July 6. The lake was lower on November 2, than at any time since 1871, when the marshes around the lake were drier than in 1895. Since November 2, the lake has been rising until, on December 25, it was fifteen and three-quarters inches higher than on November 2.

In May, 1891, the lake was higher than at any time during the past twenty years. The difference between well-remembered high water marks of that time and the level of November 2, 1895, is four and one-half feet, which is the maximum fluctuation during recent years. Each spring since 1891, has found the level of the lake lower than during the preceding spring. This gradual lowering of the level of the lake has decreased its area and has shown marked changes in the marsh land along the margin of the lake. Four years ago the water in Conkling Bay covered an area a half-mile in diameter, now it is reduced to three hundred feet in diameter; a small shallow lake just west of Conkling Bay contained water throughout the year, now it is dry and growing good crops; fields lying west of the channel were almost marsh land, the crops being greatly damaged by

water, but during the past two years no difficulty has been experienced in tilling them; two or three feet of water flowed over the Gordoniere Marsh, which is now dry with beach lines forming along its margin; and boats were rowed over all parts of the Johnson Marsh, while at present hardly any of its surface is submerged.

CONSULT HYDROGRAPHIC MAP NEXT TO FRONT COVER.

TEMPERATURE OF TURKEY LAKE. BY J. P. DOLAN.*

In making these observations a Charles Wilder standard, protected, thermometer was employed. They were begun the 13th of July, during which month four soundings were taken in the deepest parts of the lake from the surface to the bottom at every five feet. Then on October 5 two records were made at about the same points, and again on November 2.

September 17 a rain guage was set up and from that day to the present a regular record of temperature, precipitation, direction of wind and rise and fall of lake has been kept, but the observations have been confined to the northwest part of the lake; properly, Syracuse Lake.

I. TEMPERATURES OF TURKEY LAKE, 1895.

	JULY.				OCT. 5.		NOV. 2.	DEC. 14.	DEC. 24.
	INDIANA UNIVERSITY BIOLOGICAL STATION.				I. U. BIO. STAT'N.	JARRETT'S BAY.	I. U. BIO. STAT'N.	BLACK STUMP POINT.	
	13th, 10 A. M.	16th, 8:45 A. M.	17th, 9:30 A. M.	23d, 8:45 A. M.	11 A. M.	1:45 P. M.	11:10 A. M.	10 A. M.	
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	
Air	81½	83½	78½	72	65		50	28	
Surface	74	75	75	76½	60½	61½	43	34½	
5 feet					60	60¼		34½	
10 "	73	74	75	71	60	59	43	34½	
15 "	72½	74	74½	70	59	59			
20 "	71	71	73½	67½	58½	58½	43		
25 "	68	65	68½	61½	58½	58½	43½	35	
30 "	65	63	68½		58½	58½			
35 "	60	62		58½	58½	58½		35½	
40 "	60	60			58½	58			
45 "	59	57		58	58½	58		35½	
50 "	59			58	58½	58			
55 "	58				58½	58			
60 "	58			58	58¼	57½			
65 "	58			58	58	56¼			
67½ "						53¼			

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*Contributions from the Zoölogical Laboratory of the Indiana University, No. 15.

VI. SUMMARY OF SOUNDINGS OF TURKEY LAKE.

	Difference in Degrees First 20 ft.	20 to 25 ft.	25 to 30 ft.	30 to 35 ft.	35 to 40 ft.	40 to 45 ft.	45 to 50 ft.	50 to 55 ft.	55 to 60 ft.	60 to 65 ft.	Total.	Maximum.	Minimum.	Mean.	Average.
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
I. U. Bio. Station	3	3	3	5	2	2	2	2	2	2	16	74	58	66	71.9
July 13	...	...	...	...	...	*3	...	...	...	...	...	...	...	...	...
July 16	4	4	2	1	2	3	...	...	...	...	16	75	57	69	66½
July 23	6½	2½	6	...	3	...	...	...	...	...	18½	70½	58	67½	65.06
Oct. 5	2	...	...	...	...	...	...	...	½	½	2½	60½	58	59½	58.84
Nov. 2, A. M.	0	½	0	0	0	½	...	...	...	...	...	...	...	...	...
Nov. 2, P. M.	0	0	0	0	0	0	0	0	0	0	0	43	43	...	...
Dec. 14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dec. 24	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Bottom.

II. TURKEY LAKE TEMPERATURES, 1895.

September	22	23	24	25	26	27	28	29	30							
Air	86	45	37			55										
Surface	73	68	65	69	68	...	...	...	56							
Bottom	69	69	68	67	67	...			57							
Precipitation		.01		1.40			.03	.09		Total in ches 1.53						
October	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Air	56	58	68	68	65	62	64	45	38	45	49	45	40	54	48	46
Surface	54	...	63	60½	60½	57½		56	55	53		62	51½		53	52
Bottom	55	...	58	56	58½	56		56½	56	53½		52½	51	...	53	52½
Near shore	...			...				48	...	...	...	45	47	...		50
Precipitation	...	...		...	...	...	...		...			...	...	...	...	...
October	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
Air	45	49	26	28	28				60	60	48	40	38	34	34	
Surface	51			46	46½	...		...		45	44	43			39	
Bottom	51½	...	...	48	47	...	...			46½	46	44			39	
Near shore		...	...	40	45	...	...	...	...	40			...	...	...	
Precipitation	...	...	...		...	...	...	...	...	...	...	...		...	...	
November	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Air	30	22	54	60	61	60	60	45	32	32	28	26		...	...	...
Surface, 25 ft	38	43	43	41½	42	43	43	43	42	...	42½			...	...	...
Bottom, 25 ft	43	43	43	42	41	45	43	43	44	43	...	43	...	...	...	...
Surface near shore	...	36	...	...	42	...	50		38		...	...	...		...	...
Precipitation	...	...		...	...	.03	.78	1.10	...	...	...	...	.02	...	.07	...

November	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Air	..	52	34	22	20	35	33	35	35	22	16	35	36	32
Surface	..	43½	41	39	.	..	39	*	*	*	.....	....	...	34
Bottom	.	43	42	39	...	.	39	*	*	*	38†	...		35
Surface near shore		46	38	34	.		...	*	*	36†	36‡		.	...
Precipitation	.		......	.....	. .	......		..	..	..	....	..		.....

December	1	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18
Air { 7 30 A.M.		6		12	36	28	24	28	32	18	2	28	32	24	40	45
Air { 5 00 P.M.	....	12		26	33	24	18	26	36	20	24	36	26	39	43	52
Surface		...	..	34	33	33	33	33	34	33¼	..	34¼	34		33¼	33¼
Bottom	..			35	36	35	35	36	36	35¼		35¼	35	..	35	35
Near shore	..	34	.	...	32	33	33		..	.		..	..	..		...
Precipitation	.56		.07					..	.11	.	.		.07	. .	.13	1.15

December	19	20	21	23
Air { 7 30 A.M.	52	52	40	.
Air { 5 00 P.M.	54	52	39	
Surface	33¼	35¼	37	.
Bottom	35	37½	37	
Near shore		43		38
Precipitation	1.87	.96	.12	.58

* Broken thermometer. † Under ice. ‡ Common thermometer.

SUMMARY OF TEMPERATURES.

		September.		October.		November.		December.	
		Date.	Deg.	Date.	Deg.	Date.	Deg.	Date.	Deg.
Maximum.	Air	22	66	3	66	5	61	19	54
	Surface, 25 ft	22	73	3	63	18	43⅓	21	37
	Bottom	22	69	8	56⅓	26	45	20	37½
Minimum.	Air	24	37	19	26	27	16	{ 6 / 13	12 / 2
	Surface, 25 ft	30	56	31	39	30	34	7, 8, 9, 10	33
	Bottom, 25 ft	30	57	[illegible]	39	26	36	6, 8, 9, 15, 17, 18, 19	35
Averages.	Air	......	56	......	47.8	......	36.7	......	31[illegible]
	Surface	......	66⅔	......	51.7	......	41.2	......	33[illegible]
	Bottom	......	66½	......	51.57	......	41.93	......	35[illegible]

N. B.—Water general average for three months higher than air.

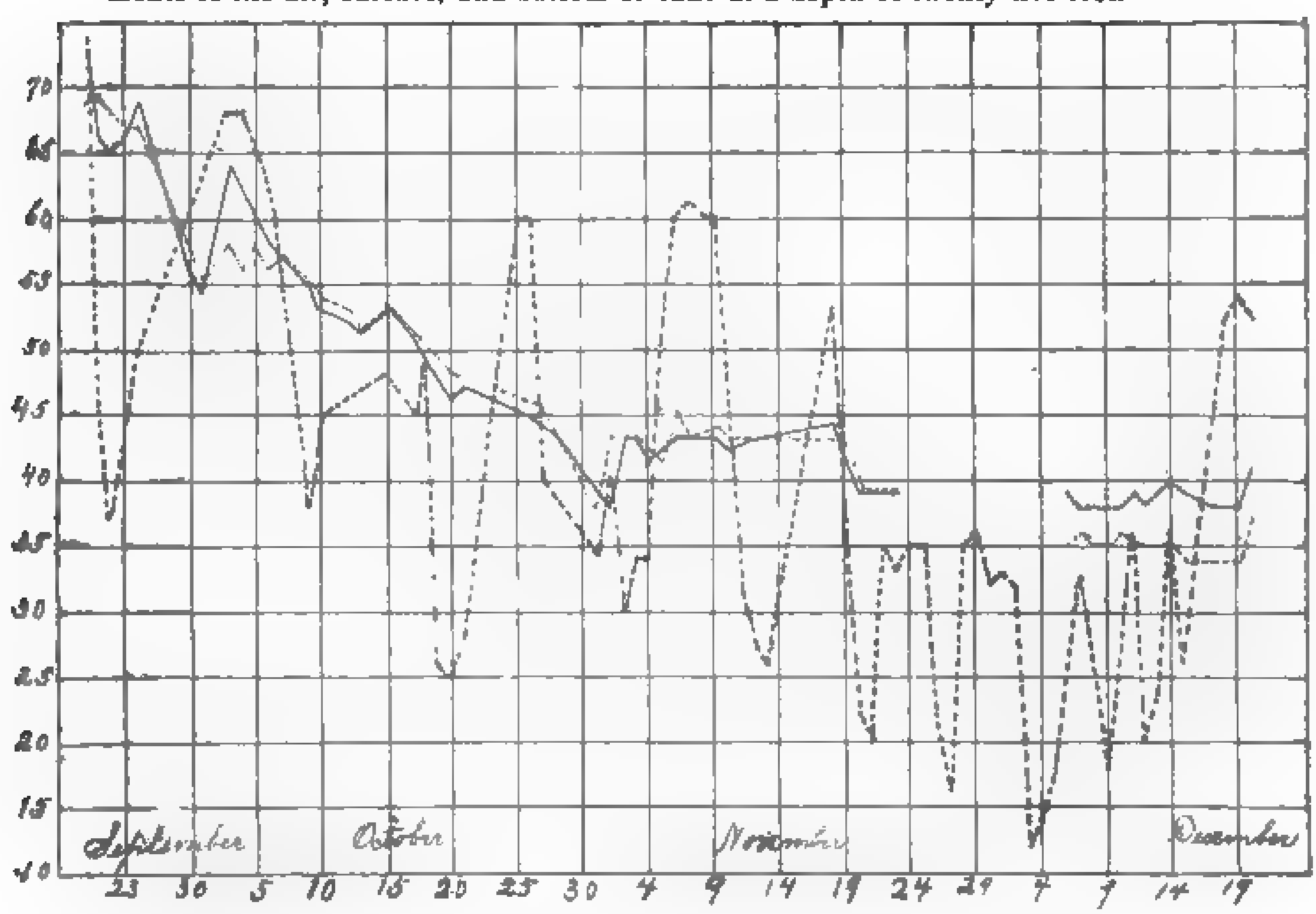
	Air.	Surface.	Bottom.
Grand average for four months	42.94	48.37	48.67

From December 3 to noon of the 20th the lake was covered with ice. During this period the surface temperature varied from 33° to 34½° and the bottom from 35° to 36°.

At 5:00 P. M. of the 20th, ten hours after the ice started to move in a body from the lake, the surface showed 35½°, a gain of 2½°; the bottom 37½°, another gain of 2½°, and in the shallow water, fifty feet from south shore, where it had been 32°, 33°, 33° on the 7, 8 and 9th respectively, it was now 43°, a gain of 10°.

The next day surface and bottom both registered 37° degrees at the twenty-five-foot station.

The results of these observations are embodied in the accompanying profile chart, in which it has been attempted to show the absolute and relative movements of the air, surface, and bottom of lake at a depth of twenty-five feet.



Temperatures from September 23 to December 23. Broken line, temperature of air; dotted line, temperature of water 25 feet below surface on the bottom; continuous line, temperature of water at the surface at the same place.

(*a*) A few well-known facts are emphasized, the variableness of the atmosphere and the persistence of the water; that water is a poor (*b*) radiator and an indifferent conductor of heat, and responds slowly to atmospheric changes.

(*d*) It shows also that the great volume of Syracuse lake at no time has been stagnant, but that a condition of activity has obtained throughout the entire period of observation.

(*c*) For the four months in which a large number of observations were made the general average of the water, both surface and bottom, is higher than that of the air.

A difference of 10° between the water one foot deep near the shore and the surface mid-lake during a rain the day the ice left the lake, shows that the surface drainage is no small factor in winter and spring in raising the temperature of the whole body.

PART II. THE INHABITANTS OF TURKEY LAKE.*

Plankton.

By plankton, Hensen, the author of the word, means everything floating in the sea and passively driven about by the waves and currents. Haeckel includes under plankton all organisms swimming in the sea. Haeckel says: "The totality of the swimming and floating population of the fresh water may be called limnoplankton." Limnoplanktonic studies have been made whenever a collector scooped for protozoa, diatoms or other minute organisms. Planktonic studies of this sort have been carried on for a long time. Recently plankton has been studied in a new way, first in the ocean and more recently in fresh water. This more recent study has been the quantitative and qualitative estimation of the plankton in a given volume of water. There seem to have developed in a remarkably short time two schools of planktonists, the one headed by Hensen asserting that planktonic organisms are uniformly distributed, the other, headed by Haeckel, being equally sure that planktonic creatures are to be found in clouds or schools. We are interested in plankton only in so far as it is part of the environment of the vertebrates inhabiting the lake. That it is not an unimportant element of the environment is due to the fact that it forms the primitive food of most of the fishes and that at the most plastic period in the life of the individual. The amount of plankton, as well as its composition from year

*Contributions from the Zoölogical Laboratory of the Indiana University, No. 16.

to year, is therefore of prime importance in the search for the causes of the differences in the same fish in two contiguous lakes or in two successive years in the same lake.

Our plankton apparatus was completed too late to enable us to make any systematic measurements, especially as our planktonist was actively engaged in the physical survey of the lake. But plankton was collected and some of its different constituents will be reported upon.

A good historical account of planktonic studies, as well as exact definitions, are to be found in the Planktonic Studies of Haeckel, translated by G. W. Field, and published in Commissioners' Report, 1889-91, U. S. Com. Fish and Fisheries, pp. 565-641.

In the following sketch several groups of animals are not at all considereds and others but briefly. The only groups found in the lake of which we approximate a complete list are the fishes, batrachians and reptiles. Deficiencies will be removed in subsequent reports when a classification of the material into *littoral*, *bathybial* and *pelagic* will also be attempted.

PROTOZOA.

The *Protozoa* were not represented by a large array of species during the summer. No detailed work has been done on them as yet, but I want to mention two characteristic forms.

The most striking *Protozoan* is *Ophridium*. It is found in clumps varying from microscopic minuteness to the size of walnuts, and in different parts of the lake the pebbles and exposed parts of clam shells are covered with these colonies to such an extent as to suggest young lettuce beds.

Ceratium hirudinella is as striking and abundant in the *pelagic* regions as *Ophridium* is in the *littoral*.

In this connection two plants may also be noticed.

Rivularia is very abundant during the whole summer. It is conspicuous in calm weather, when it rises to the surface. Toward the end of August and in early September it collects in such numbers as to form large patches and streaks, forming a true *Wasserblüthe*.

Various forms of *Palmella* are abundant during the whole summer, and in October, when *Rivularia* has disappeared, it forms large patches on the surface forming the *Wasserblüthe* of the late fall.

PORIFERA.

Sponges are not abundant in the lake. They are found in small patches on boards, sticks and other things near the margins of the lake. They grow much more luxuriantly in the outlet of the lake where they sometimes form patches several square feet in extent.

CNIDARIA.

Hydra viridis L. Specimens of *hydra* were exceedingly rare. On one occasion a few were taken on a submerged stick near Black Stump Point.

PLATHELMINTHES.

Flat worms were not systematically collected and none of these collections have been identified. Of *Turbellarians* there were several species. *Amia calva* is infested by a tape worm and by a *Distomum*.

NEMATHELMIA.

No attempt was made to collect thread worms. *Gordius* is exceedingly abundant on the margins during the latter part of summer. I counted as many as twelve in the area of one foot square.

ANNELIDA. BY BESSIE C. RIDGLY.

No *Chaetopoda* were collected.

No systematic attempt was made to get large numbers of leeches, but specimens were preserved whenever found. In the classification I have followed Verrill.

Nephelis quadristriata Grube. Thirteen specimens from Turkey Lake.

Nephelis fervida Verrill. Fourteen specimens.

Clepsine parasitica Diesing. Three specimens.

Clepsine ornata stellata Verrill. This species was not found in Turkey Lake. Two specimens were taken in Tippecanoe Lake.

Clepsine ornata rugosa Verrill. Four specimens.

Clepsine ornata variety d Verrill. Ten large specimens corresponding with the second specimen described by Verrill were found, most of them on turtles.

Clepsine papillifera Verrill. One specimen.

Clepsine papillifera carinata Verrill. Three specimens. One of these, one-half inch long, was found under a stone in front of the laboratory. A number of young were attached to it.

Clepsine pallida Verrill. One specimen.

Clepsine pallida variety b Verrill. One specimen.

Clepsine elegans Verrill. Five specimens.

ROTIFERA. D. S. KELLICOTT.

I received in September three vials of plankton, from Mr. Chancey Juday with the request to report upon the *Rotifera* found therein. The vials were marked and described as follows: "I. Contains plankton caught at the surface of the water of Wawasee Lake, Indiana, by using a plankton net; taken August 28, 1895; killed in picro-sulphuric acid; washed in 35 per cent. and 50 per cent. alcohol and preserved in 85 per cent. alcohol." "II. Depth of haul, 60 feet (Wawasee); depth of water, 65 feet; taken July 20, 1895; killed in Flemming's Fluid; washed in 35 per cent. and 50 per cent. alcohol, and preserved in 85 per cent. alcohol." "III. From Tippecanoe Lake; depth of haul, 110 feet; depth of water, 117 feet; taken August 7, 1895; killed in Flemmings's Fluid; washed in 35 per cent. and 50 per cent. alcohol, and preserved in 85 per cent. alcohol."

I find that the *Rotifera* were much better preserved in II and III than in the first. The illoricate species in I were scarcely recognizable; in fact three species found in this vial I have not been able to place more nearly than the probable genus. Those in II and III have all been satisfactorily identified. While the whole number recognized in these collections is not large some interesting facts are brought to light. Three species not hitherto reported from this country are among the number, and others rarely. It is certain that the *rotiferal* fauna of these lakes is rich and will yield many unique forms as a reward to any student who may be able to work in the region, to take and study them in the fresh state, and in all their varied relations and situations of residence.

I shall enumerate, with remarks, the species found in each haul separately, although it will cause some repetition, and in the order of Hudson and Gosse's *Rotifera*, without citing the bibliography farther than a description where the partial bibliography, however, will usually be found.

I.

1. *Floscularia mutabilis* Bolton. Not infrequent. It is quite unexpected that a floscule should occur among pelagic species, and yet there are four known species of these *Rhizota* that cut loose and become sailors. Mr. H. S. Jennings has found three of them in St. Clair and lakes of Michigan. Of this one he says: "Very common in towings from Lake St. Clair, either at the surface or near the bottom. Hudson and Gosse, I, 56.

2. *Œcistes brachiatus* Hudson. A large number were found, but it was impossible to identify them surely. The tube conforms to the figures and descriptions of that of *Brachiatus;* it is cylindrical, smooth, compact, perfectly hyaline,

often containing a slight amount of adhering matter, often containing several eggs, which, however, are not so elongate as the figures represent those of *Brachiatus;* the long narrow foot and the long non-retractile antennæ agree well with the type. I am pretty confident that it is *Brachiatus*, yet I am surprised to find so many of them, or any of them, in a surface tow, as it is evidently normally anchored; perhaps they were attached to floating algæ which apparently are not uncommon in the lake. H. and G., I, 83.

3. *Philodina megalotrocha* Ehrenberg. Numerous. I have often taken it at a distance from land, particularly in shallow lakes or among floating algæ. H. & G., I, 101.

More than one species of *Rotifer* which could not by any means be identified were present.

4. *Sacculus viridis* Gosse. Rare. H. and G., I, 124.

5. *Polyarthra platyptera* Ehrenberg. Many seen. The serrations on the edges of the broad plates are coarse and more distant than in the type. H. and G, II, 3.

6. *Dinocharis pocillum* Ehrenberg. One individual. It is a bottom feeding species and rarely occurs in a surface tow. H. and G., II, 71.

7. *Dinocharis collinsii* Gosse. One. Bottom feeding species. It has not been observed in this country before. No species exceeds it in beauty. I could not make out the pair of spines on the foot and the edge of the lorica appears to be set with a row of small spines, rather than being serrate as described and figured. H. and G., II, 72.

8. *Anuræa cochlearis* Gosse. Exceedingly abundant. Our form differs slightly from Gosse's figure since the mesal ridge of the lorica does not extend straight from end to end, but has a decided angle at each pair of facets, the anterior median one is not divided. H. and G., II, 124.

9. *Notholca longispina* Kellicott. Not rare. This rotiferon was first known in the water supplies of cities along the Great Lakes. Soon after it was described in 1879, it was found in Olton Reservoir, Eng., and then by Imhof in the Swiss Lakes. More recently it has been found in lakes of America. Mr. Levic reports finding the eye spot double, or so far separated as to be regarded as two eyes. I have seen several in these collections with the same peculiarity.

II.

1. *Polyarthra platyptera* Ehrenberg. Few.*

2. *Triarthra longiseta* Ehrenberg. Comparatively few in this vial. H. and G., II, 6.

3. *Ploesoma lenticulare* Herrick. Very many. It occurs in the lakes of Europe. In this country it has been reported only from Lake St. Clair, both in bottom and surface tows (Jennings). Zoöl. Anz., Bd. 10, 577.

4. *Brachionus militaris* Ehrenberg. Rare. I have found this an abundant species in ponds of western New York; it is a good sailor, preferring small seas, however. Authors have recorded the fact that the posterior spines are not in the same horizontal plane. This seems to be in relation to the habit of always turning on its long axis as it swims; they appear to bore their way through the water. H. and G., Sup. 82.

5. *Anuraea cochlearis* Gosse. Many, but far less numerous than in I.

6. *Notholca longispina* Kellicott. More abundant than in I.

III.

1. *Asplanchna priodonta* Gosse. Quite numerous. Jennings reports this fine species as abundant in Lake St. Clair, both at the surface and in deep water. H. and G., I, 123.

2. *Polyarthra platyptera* Ehrenberg. Several found.

3. *Triarthra longiseta* Ehrenberg. Numerous.

4. *Diaschiza valga* Gosse. Only one seen. It appears to agree well with the figure and description. H. and G., II, 77.

5. *Anuraea cochlearis* Gosse. Not common.

6. *Notholca longispcia* Kellicott.

CLADOCERA. A. BIRGE.

The following letter on the *Cladocera* of Turkey Lake has been received:

I enclose list of *Cladocera* in your bottles.

1. *Holopedium gibberum Zad.*, few; *Daphnia hyalina and retrocurva* Forbes. Much *algal* material, chiefly *Clathrocystis.*

2. *Holopedium gibberum D. retrocurva Sida. crystallina O. F. M., Diaphanosoma brachyurum* Liev.

3. *D. retrocurva*, extreme form of hemlet, like that of Lake Mendota, *Diaph. brachyurum.* Material looks as if it had been dried.

4. *D. retrocurva Diaph. brachyurum Ceriodaphnia lacustris* Birge. *Leptodora hyalina Lillj.*, *Holopedium gibberum*, one specimen.

5. *Diaph. brachyurum*, *Sida crystallina*, *Cer. lacustris.*

6. *Holo. gibberum*, *Diaph. brachyurum*, *D. retrocurva*, *Algae* like No. 1.

7. *Diaph. brachyurum*, *D. retrocurva*, *Cer. lacustris*, *Leptodora hyalina.*

Great number of *Epischura lacustris*, far more than I ever saw before.

8. *D. retrocurva*, *Sida crystallina*, *Diaph.*, *brachyurum.*

9. *Diaph. brachyurum*, *D. retrocurva*, not an extreme form, *Daphnia longiremis* Sars, *Sida crystallina*, very few.

Most of these species are predictable, that is, they would be found in almost any pelagic collection from this general region. I do not think that *H. gibberum* has been found so far south as this collection shows it. *Cer. lacustris* has not been found outside of Wisconsin before. The specimens are much more thin-shelled than those which I have seen before. It is remarkable that *D. retrocurva* is far more numerous than is *D. hyalina.* The reverse has been true in all lakes which I have studied, except Pine Lake, Wisconsin. In most of the bottles examined it was difficult to find *D. hyalina*, while the other species was quite plenty. It is to be noted that this species of Forbes is really a variety of *D. kahlbergiensis* Sch, but as the form is well marked and the full name intolerably long, I have quoted it by the varietal name only.

D. longiremis has been found before only in Lake Geneva, Wisconsin. In size, form and shape of head it exactly agrees with my figures and description in Trans. Wis. Acad.; Vol. IX, p. 299, pl. XI, figs. 4-10.

In all bottles there were many *Cyclops* and *Diaptomus*, and in one, as already noted, large numbers of *Epischura.*

I should gladly write more, but have been too busy for a longer report. Will send bottles to Marsh for Copepods and try to get up a full account later.

Very truly,

E. A. Birge.

Data of the lots of specimens numbered in the above letter:

I. Taken Aug. 28, 1895, between 1 and 2 P. M., from surface of water. Killed in picro-sulphuric acid. Preserved in 70 per cent. alcohol.

II. Taken June 27, 1895, at 8 A. M. Skimmed from surface of water, using No. 2 Bolting Cloth. Killed in picro-sulphuric acid. Preserved in 70 per cent. alcohol.

III. Taken Aug. 14, 1895, at 5 P. M. Depth of haul, 60 ft. Killed in picro-sulphuric acid. Preserved in 70 per cent. alcohol.

IV. Taken July 27, 1895. Skimmed from surface of water, using No. 2 Bolting Cloth. Killed and preserved in 10 per cent. formalin.

V. Taken June 27, 1895, at 8 A. M. Skimmed from the surface with a No. 2 Bolting Cloth net. Killed and preserved in 10 per cent. formalin.

VI. Taken July 29, 1895. Depth of haul, 25 ft. Killed and preserved in formalin.

VII. Taken July 12, at night. Surface skimming, using a No. 2 Bolting Cloth net. Killed and preserved in 10 per cent. formalin.

VIII. Taken Aug. 1, 1895, at 9 A. M. Depth of haul, 10 ft. Killed in Flemming's fluid. Preserved in 70 per cent. alcohol.

IX. Taken Aug. 7, 1895, at 4 P. M. Depth of haul, 110 ft. Killed in Flemming's fluid. Preserved in 70 per cent. alcohol.

I, II, III, IV, V, VI, VII, VIII are from Turkey Lake or Lake Wawasee; IX is from Tippecanoe Lake.

DECAPODA.

The following crayfishes from Turkey Lake were identified by Mr. W. P. Hay, of Washington, D. C.:

Cambarus blandingii acutus Girard.

Cambarus propinguus Girard.

Cambarus virilis Hagen.

ON A SMALL COLLECTION OF MOLLUSKS FROM NORTHERN INDIANA. BY R. ELLSWORTH CALL, M. D., PH. D.

The mollusks herewith reported on were collected by the members of the Indiana University Biological Station during the past summer. The region is sufficiently well characterized in the report of Dr. Eigenmann, the Director of the Station, and it is necessary here only to allude to its salient features.

The locality is on the divide separating the drainage areas of the Great Lakes and the Wabash River. In certain places the two drainages are practically identical and thus afford opportunity for the intermingling of the two faunas. The lakes and streams are all well within the limit of glaciation in former ages and their beds and shores are boulder-covered or lined. The bottoms of shallower portions of the lakes are gravelly or muddy, while the deeper portions are either muddy or sandy. Corresponding with these physical factors are certain features of molluscan distribution and modification, which it is the object of these notes to adduce and emphasize.

UNIONIDÆ.

Anodonta decora Lea. Two specimens of this form were found, both of which were obtained in Syracuse Lake. The specimens were very much more fragile and far thinner than is usual for this species, even when secured from lakes and ponds. The epidermis is quite pale, the lines of growth crowded, and the nacreous deposit very white. Forms from sluggishly flowing streams in southern Indiana and elsewhere in the Ohio basin are very highly colored, both interiorly

and without. As in other members of this family from these lakes the optimum habitat does not appear to be here. Many of the shells are coated with heavy deposits of calcareous matter, indicating a chemic condition of the water that is unfavorable to the normal development of the several species.

Anodonta ferussaciana Lea. One specimen from Turkey Creek; three specimens from Syracuse Lake.

The resemblance of these shells to the *Anodonta subcylindracea* is very marked indeed. The lake form is lighter both in texture and color than the one specimen from the creek.

Anodonta footiana Lea. Three specimens from Syracuse Lake; one specimen from Turkey Creek.

The shells submitted are very characteristic of this form, which may not, ultimately, be separated from *Anodonta lacustris* Lea. Like its congeners from the same locality the lake form is very pale in color and unusually thin and fragile. A very interesting fact is illustrated in the littoral distribution of this species and *Sphaerium* from the same lake. Those which occur in comparatively deep water are very much thinner and lighter in color than the shore forms. Also, those which are found on the northern shores are thinner and more fragile than those on the southern beach. The reason possibly may lie in the prevailing winds, which are from the northeast. The southern beach is also more gravelly than the northern. The conditions of environment then, in this case, favor thicker development of the shell in the forms living on the southern beach; they need greater powers of resistance, are subjected to rougher conditions of habitat and this finds expression in heavier secretion of nacreous material. The shells which live at the lake's bottom are also beyond the disturbing influence of waves and being deeply imbedded in mud develop to greater size, but with thinner shells.

Margaritana calceola Lea. A single dead specimen, from Turkey Creek.

This specimen is a very characteristic one, the deposit of calcareous matter on the inner surfaces of the valves being marked; this is a pathologic feature, well marked in the type specimens which Dr. Lea studied. This form and *Margaritana deltoidea* Lea are synonyms.

Margaritana rugosa Barnes. Represented by eight specimens from Turkey Creek, all of which are characteristic.

Unio coccineus Lea. One specimen, dead, from Turkey Creek.

The nacre of this shell is quite white, a fact true of the majority of shells which fall under this form, though the type-form was beautifully pink. It is often found in collections labelled *Unio rubiginosus* Lea, but is easily separated

by the characters of the cardinal teeth and the rounded, nonangulate character of the posterior slope. In *Unio rubiginosus* there is a well marked ridge extending quite to the posterior margin. The flat and white nacred form also may occasionally be seen in collections as *Unio gouldianus* Lea, now a well recognized synonym.

Unio fabalis Lea. Twelve specimens from Tippecanoe Lake.

This is one of the smallest of our *Unios*. The shells submitted do not present any variant features other than the very light coloration so characteristic of all the lake shells which we have seen. *Unio lapillus* Say is a synonym.

Unio gibbosus Barnes. This form is represented by three specimens from Turkey Creek. These are all much thinner and lighter than the same species from the Ohio and Wabash rivers, in both of which it is a common shell. It seems to be very abundant in certain of the lakes of northern Indiana, notably Lake Maxinkuckee. The nacre of these three individuals is very dark purple. Similar shells to these probably have led to the reference of *Unio complanatus* Solander to the western fauna.

Unio iris Lea. Two characteristic specimens from Turkey Creek. Like its near relative—which is probably also a synonym—*Unio novieboraci* Lea, this shell occurs most commonly and abundantly in creeks and other small streams. It most affects soft muddy bottoms in rather still waters.

Unio luteolus Lamarck. Ten specimens from Syracuse Lake; seven specimens from Turkey Creek.

This species is the most widely distributed shell of the family. It occurs in every stream, lake and pond in Indiana in which shell life of any sort occurs at all. It is also the most abundant *Unio*, and, correlated with abundance and wide distribution, is a range of variations that are of the greatest import in evolutionary processes. All the shells submitted, particularly those from Syracuse Lake, are well covered, posteriorly, with carbonate of lime in heavy masses. The lake specimens also have beautifully marked green rays widely separated over a polished disk, thus constituting them the form to which Anthony gave the name of *Unio distans*. The epidermis usually has the peculiar coloration of forms which live in muddy bottoms, though in the lake specimens the epidermis is, for some hidden chemical reason, quite red posteriorly. This peculiar coloration has often been noticed in shells submitted to us from the lake region of Northern Indiana.

Unio occidens Lea. Nine characteristic specimens from Turkey Creek. None present features different from shells found elsewhere in the State.

Unio pressus Lea. One specimen from Turkey Creek.

A great many shells of this species have been seen from time to time from various places in Indiana. Very many of them, as this one well does, present a peculiar diseased or pathologic condition of the cardinal teeth not altogether unlike the condition exhibited by the interior surface of *Margaritana calceola*. In this instance the cardinal teeth are nearly destroyed and are represented by distorted and imperfect vestiges. It would be interesting indeed if the Station, during the next season, could investigate this phenomenon as a study in the physiology of *Unio*, a field yet uncultivated.

Unio rubiginosus Lea. Two specimens from Turkey Creek, one of which is pathologic

These shells are intermediate between *Unio trigonus* Lea and typical *Unio rubiginosus* Lea. They are somewhat more trigonal than the latter shells are commonly found, and, on the other hand, are less heavy and trigonal than the ponderous river form. The whole group is sadly confused and needs painstaking revision.

CORBICULADÆ.

Sphærium rhomboideum Prime. A single specimen only was taken, from Turkey Lake, in muddy bottom and in comparatively deep water. The specimen is very much thinner than usual.

Sphærium solidulum Prime. Ten specimens from Turkey Lake. These are all smaller than common and quite heavy; they came from the beach at Vawter Park.

FRESH-WATER UNIVALVES.

Amnicola porata Say. Eight specimens of this small univalve were obtained in Tippecanoe Lake. Neither it nor others of the univalves found present any characters different from shells found in streams throughout the State.

Campeloma decisum Say. Five dead specimens from Turkey Lake.

Campeloma integrum Dekay. One dead specimen from Turkey Creek.

Campeloma rufum Haldeman. About twenty specimens from Tippecanoe Lake; thirteen, one of which was reversed or sinistral, from Turkey Creek.

There is no difficulty in recognizing these several forms, though tyros annually make the discovery that there are no valid species but one. *Campeloma rufum* differs from both the others constantly by the outlines of the whorls, the shape and color of the aperture, the pink character of the apical whorls, a feature which is best illustrated in the very young and which is a constant character, and in the polished epidermis, which presents a character seen in no other member of the genus. Reversed forms are not uncommon, but yet may be justly considered

rare. The type of the genus is a reversed specimen of *Campeloma ponderosum* from the Ohio River, taken by Rafinesque near Louisville, Ky.

Planorbella campanulata Say. Very abundant in all parts of Tippecanoe Lake.

Helisoma trivolvis Say. Two specimens from Turkey Lake; three specimens from Turkey Creek. The form submitted from Turkey Creek is a very large one, and is rather heavy in texture. The species must be very abundant in favorable localities.

Limnophysa humilis Say. Five specimens of this small limnæid were obtained along the shores of Turkey Lake.

Limnophysa caperata Müller. A single specimen of this common form only was secured. It came from Turkey Lake.

Physa ancillaria Say. Four specimens taken alive, entirely white, from Turkey Lake. This shell is usually honey yellow in coloration, but these specimens were a snow white.

Physa gyrina Say. Only two specimens of the "tadpole" physa appear in the collections, and these came from Tippecanoe Lake. It is one of the most widely distributed and most abundant of the Limnæidæ.

Goniobasis pulchella Anthony. Nine specimens from Turkey Lake; very abundant in Tippecanoe Lake, from which many dead specimens were submitted. This form is widely distributed throughout Indiana. Sometimes associated with it is *Goniobasis livescens* Menke, a form decidedly characteristic of the lake drainage.

Pleurocera subulare Lea. Very abundant in Lake Tippecanoe, from which many dead examples were seen.

Valvata tricarinata Say. A single specimen from Tippecanoe Lake.

LAND MOLLUSCA.

Limax campestris Binney. Four specimens of this widely distributed form were obtained from Vawter Park.

Succinea obliqua Say. This species is represented by ten alcoholic specimens. All taken at Vawter Park.

Zonites arboreus Say. Three alcoholic specimens from Vawter Park.

None of the univalves present features worthy of special mention. The whole collection is rather the result of incidental work than of careful collecting, and is to be taken as somewhat indicative of the wealth of molluscan life in favored localities in Indiana. It is submitted as a local contribution, in the form of a special report, that may help to a general knowledge of Indiana mollusks. Cincinnati, Ohio, November 3, 1895.

THE ODONATA. BY D. S. KELLICOTT.

I received for identification last fall two small collections of Dragonflies from Professor Eigenmann. They have been studied and compared with a determined collection; the following species were included:

1. *Calopteryx maculata* Beauv. It occurs throughout the Eastern United States and is usually abundant wherever it is found, preferring shady streams or rivulets of spring water.

2. *Hetærina americana* Fabr. Several examples of both sexes. This species extends over a wide eastern range and is represented in the Gulf States by a well marked form known in the lists as *H. basalis*, and on the Pacific Slope by another, *H. Californica*. Flies late, often until the middle of October, in Ohio. The scarlet patches at the base of the wings of the male make it a beautiful and conspicuous insect.

3. *Enallagma hageni* Walsh. This appears to be a rare species, but has now appeared in Illinois, Indiana and Ohio.

4. *Enallagma signatum* Hagen. Extends from the Gulf to Maine.

5. *Æschna clepsydra* Say. Two males and one female (?) were sent. All the *æschnas* fly late in the season. The three species *constricta, clepsydra* and *verticallis* resemble one another so closely that they are often regarded as one species; the females can not be separated by any one as yet.

6. *Anax junius* Drury.

7. *Tramea lacerata* Hagen.

8. *Libellula basalis* Say.

9. *Libellula pulchella* Drury.

10. *Plathemis trimaculata* DeGeer.

11. *Celithemis eponina* Drury.

12. *Diplax vicina* Hagen. This is doubtless the last odonat on the wing in our latitude. In central Ohio it has been taken pairing and ovipositing as late as November 8.

13. *Mesothemis simplicollis* Say.

14. *Pachydiplax longipennis* Burm.

I am surprised at the absence of all Gomphines and that so few Agrionines are present. Collecting in the early summer would doubtless disclose several species of both groups.

Fishes. By C. H. Eigenmann.

Fishes were collected in much larger numbers than any of the other vertebrates. They will form the subject of our most extented study of variation. I present here simply a few dates on the spawning time and the distribution of the various species in the localities examined. Half of these localities are on the St. Lawrence side of the divide; the other half on the Mississippi side. To show the relation of the fauna to that of the State I present a complete list of Indiana fishes.

SPAWNING SEASONS.

Most of the fishes spawn in the spring before the Station opened. This was true of all the larger species except a few stragglers of *Lepomis pallidus*.

Noturus flavus. This species is common under boards and logs in Turkey Creek, at Syracuse. Eggs were found in all stages of development the latter half of June. They are laid in little depressions in the gravel under boards, and are apparently watched by the adult. The eggs adhere to each other in masses large enough to fill the hollow of the hand. The eggs are very flabby, the membrane being not tense, as usual in fish eggs. After hatching the young remain together in the nest, and if they are uncovered by raising the board they quickly scatter to hide under another object or under the board again if this has been turned over. The blastoderm forms a narrow nodule well separated from the yolk by a deep constriction.

Pimephales notatus. The eggs of this species are laid on the under surface of various objects submerged in the margin of the lake to a depth of one or two feet. The fish is usually found with the nest, and the immediate neighborhood of the nest is kept clean of weeds and mud. The eggs were found during the whole of June and the greater part of July. The young swim near the surface and are very abundant the latter half of June.

Fundulus diaphanus menona. On June 24 eggs of this species were dragged up by the seine from the grass of the bottom. They are bound together by filaments.

Zygonectes notatus. Many taken on June 27 in Turkey Creek were with ripe eggs.

Etheostoma caprodes. This species was spawning on May 30, a single ripe female was taken about June 25.

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Ammocoetes branchialis L. Brook Lamprey						†						
Ichthyomyzon concolor Kirkland.												
Polyodon spathula Walbaum. Spoon-bill Cat									†			
Scaphirhynchus platyrhynchus Raf. Shovel-nosed Sturgeon												
Acipenser rubicundus Le Sueur. Lake Sturgeon.												
Lepisosteus osseus L. Common Gar Pike			†		†				†			
Lepisosteus platostomus Rafinesque. Short-nosed Gar-pike			†									
Lepisosteus tristoechus Bloch and Schneider. Alligator Gar												
Amia calva L. Bow-fin, Mud-fish, Dog-fish		†	†	†	†				†			
Ictalurus furcatus Le Sueur. Chuckle-headed Cat												
Ictalurus punctatus Rafinesque. Channel Cat												
Ameiurus lacustris Walbaum. Great Cat-fish												
Ameiurus natalis Le Sueur. Yellow Cat	†		†			†	†	†	†	†	†	
Ameiurus nebulosus Le Sueur. Common Bullhead, Horned Pout									†			
Ameiurus melas Rafinesque												
Leptops olivaris Rafinesque. Mud Cat												
Noturus flavus Rafinesque.						†						
Schilbeodes exilis Nelson												
Schilbeodes miurus Jordan												
Schilbeodes eleutherus Jordan												
Schilbeodes gyrinus Mitchill	†		†	†		†						
Schilbeodes nocturnus Jordan and Gilbert												
Ictiobus cyprinella Cuv. and Val. Common Buffalo Fish												
Ictiobus urus Agassiz. Razor-backed Buffalo.												
Ictiobus bubalus Rafinesque. Sucker-mouthed Buffalo												
Carpiodes carpio Rafinesque												
Carpiodes difformis Cope												
Carpiodes velifer Rafinesque. Quill-back												
Cycleptus elongatus Le Sueur. Black Horse												
Catostomus catostomus Foster. Northern Sucker.												
Catostomus commersoni Lacépède. Common Sucker, White Sucker		†				†						

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake Creek.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam)	Tippecanoe River (Below Dam)	Shoe Lake.
Catostomus nigricans Le Sueur. Hog Sucker						†						
Erimyzon sucetta oblongus Mitchill. Ch		†	†	†		†	†	†	†	†	†	
Minytrema melanops Rafinesque. Striped Sucker						†						
Moxostoma anisurum Rafinesque. White-nose Sucker												
Moxostoma aureolum Le Sueur												
Moxostoma breviceps Cope.												
Placopharynx duquesnii Le Sueur												
Lagochila lacera Jordan and Brayton. Hare-lip Sucker												
Campostoma anomalum Rafinesque. Stone Roller						†						
Chrosomus erythrogaster Rafinesque. Red-bellied Minnow												
Hybognathus nuchalis Agassiz.												
Pimephales promelas Rafinesque												
Pimephales notatus Rafinesque			†			†		†	†			†
Cliola vigilax Baird and Girard. Bull-head Minnow												
Notropis anogenus Forbes			†									
Notropis bifrenatus Cope.			†			†						
Notropis heterodon Cope			†	†		†	†	†	†			
Notropis microstomus Rafinesque			†									
Notropis cayuga Meek												
Notropis boops Gilbert												
Notropis hudsonius Clinton. Spawn-eater									†			
Notropis whipplei Girard. Silver-Fin												
Notropis megalops Rafinesque. Common Shiner		†	†			†	†	†	†	†	†	
Notropis jejunus Forbes												
Notropis ariommus Cope												
Notropis ardens Cope. Red-fin												
Notropis atherinoides Rafinesque												
Notropis arge Cope												
Notropis dilectus Girard												
Notropis rubrifrons Cope												
Ericymba buccata Cope												
Rhinichthys atronasus Mitchill												
Hybopsis dissimilis Kirtland												
Hybopsis amblops Rafinesque												
Hybopsis storerianus Kirtland												

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Hybopsis watauga Jordan and Evermann												
Hybopsis kentuckiensis Rafinesque. Horny Head, River Chub, Jerker.		†				†		†		†		
Hybopsis hyostoma Gilbert												
Semotilus atromaculatus Mitchill. Horned Dace, Creek Chub		†				†		†				
Phoxinus elongatus Kirtland												
Opsopœodus emiliæ Hay												
Notemigonus chrysoleucus Mitchill			†	†			‡	†	†			
Hiodon alosoides Rafinesque												
Hiodon tergisus Le Sueur. Moon-eye												
Clupea chrysochloris Rafinesque. Skip-jack												
Dorosoma cepedianum Le Sueur. Gizzard Shad												
Coregonus quadrilateralis Richardson												
Coregonus clupeiformis Mitchill												
Coregonus labradoricus Richardson												
Coregonus hoyi Gill												
Coregonus artedi Le Sueur												
Coregonus artedi sisco Jordan									†			
Salvelinus namaycush Walbaum. Trout												
Percopsis guttatus Agassiz. Trout Perch												
Amblyopsis spelæus De Kay. Blind Fish												
Typhlichthys subterraneus Girard												
Fundulus diaphanus menona Jordan and Copeland			†									
Zygonectes notatus Rafinesque. Top Minnow		†				†					†	
Zygonectes dispar Agassiz								†	†		†	
Gambusia patruelis Baird and Girard. Top Minnow												
Umbra limi Kirtland. Mud-minnow, Dog-fish	†						†	†		†		
Lucius vermiculatus Le Sueur. Little Pickerel	†	†	†	†	†	†	†	†	†	†	†	†
Lucius lucius L. Pike, Northern Pickerel												
Lucius masquinongy Mitchill. Muskallunge												
Anguilla anguilla rostrata Le Sueur. Eel												
Pygosteus pungitius L. Nine-spined Stickleback												
Eucalia inconstans Kirtland. Brook Stickleback												
Labidesthes sicculus Cope. Brook Silverside			†	†	†	†			†			
Aphredoderus sayanus Gilliams. Pirate Perch	†					†						

	St. Lawrence Basin.						Mississippi Basin.					
	Strings Lake.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe River	Tippecanoe River (Above Dam)	Tippecanoe River (Below Dam).	Sh[illegible] Lake.
Centrarchus macropterus Lacépède												
Pomoxis sparoides Lacépède. Calico Bass			†									
Pomoxis annularis Rafinesque. Crappie												
Ambloplites rupestris Rafinesque. Rock Bass, Red Eye			†	†		†		†	†			
Chænobryttus gulosus Cuv. and Val. War Mouth			†	†			†		†	†		†
Lepomis cyanellus Rafinesque. Green Sunfish			†			†		†			†	
Lepomis macrochirus Rafinesque												
Lepomis humilis Girard												
Lepomis pallidus Mitchill. Blue Sunfish			†					†	†	†	†	†
Lepomis megalotis Rafinesque												
Lepomis garmani Forbes												
Lepomis euryorus McKay												
Lepomis heros B. and G. McKay												
Lepomis notatus Agass. McKay												
Lepomis gibbosus L. Common Sunfish			†	†				†	†	†	†	†
Micropterus dolomieu Lacépède. Small-mouthed Black Bass			†			†			†	†		
Micropterus salmoides Lacépède. Large-mouthed Black Bass		†	†			†		†	†	†	†	†
Etheostoma pellucidum Baird. Sand Darter.												
Etheostoma aspellus Jordan												
Etheostoma nigrum Rafinesque. "Johnny".			†			†		†	†	†		†
Etheostoma chlorosoma Hay												
Etheostoma blennioides Rafinesque. Green-sided Darter												
Etheostoma coplandi Jordan												
Etheostoma histrio Jordan and Gilbert												
Etheostoma shumardi Girard												
Etheostoma uranidea Jordan and Gilbert												
Etheostoma caprodes Rafinesque. Log Perch, Hog-fish			†			†	†	†	†			
Etheostoma macrocephalum Cope.												
Etheostoma ouachitæ Jordan and Gilbert												
Etheostoma aspro Cope and Jordan						†		†	†			
Etheostoma phoxocephalum Nelson												
Etheostoma scierum Swain												
Etheostoma evides Jordan and Copeland												
Etheostoma variatum Kirtland												

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper.)	Turkey Lake.	Channel	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam)	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Etheostoma zonale Cope												
Etheostoma camurum Cope												
Etheostoma maculatum Kirtland												
Etheostoma flabellare Rafinesque								†				
Etheostoma squamiceps Jordan												
Etheostoma tippecanoe Jordan and Evermann												
Etheostoma iowae Jordan and Meek			†			†	†	†	†			†
Etheostoma coeruleum Storer. Rainbow Darter						†		†		†		
Etheostoma coeruleum spectabile Agassiz												
Etheostoma jessiae Jordan and Brayton												
Etheostoma fusiforme Girard												
Etheostoma eos Jordan and Copeland												
Etheostoma microperca Jordan and Gilbert			†							†	†	
Perca flavescens Mitchill. Yellow Perch		†	†	†	†	†	†	†	†	†	†	†
Stizostedion vitreum Mitchill. Wall-eye												
Stizostedion canadense C. H. Smith. Sauger, Sand Pike												
Roccus lineatus Bloch. Striped Bass												
Roccus chrysops Rafinesque. White Bass									†			
Morone interrupta Gill. Yellow Bass												
Aplodinotus grunniens Rafinesque. Fresh Water Drum												
Cottus ricei Nelson												
Cottus bairdi Girard. Miller's Thumb											†	
Cottus pollicaris J. and G.												
Cottus hoyi Putnam												
Lota lota maculosa Le Sueur. Burbot												

BATRACHIA. BY CURTIS ATKINSON.

Siren lacertina Linnaeus. A single specimen of this species was taken in the seine in the channel. Mr. Dolan secured another late in September, and afterwards, through his students, secured a nest of eleven, which were uncovered while cleaning a lot near Syracuse. These had evidently gone into winter quarters. Five of them are still alive. Turkey Lake is the most northern locality so far recorded for the siren.

Necturus maculatus Rafinesque. Three specimens of this species were secured. It is said to be abundant, but no other specimens were noted. On June 28, a number of eggs were found fastened to the lower surface of a board, which was well imbedded in the mud of the bank of Turkey Creek. The young were already quite active in the loose, flabby bags forming their covering.

Amblystoma jeffersonianum Green? A single specimen under a log near the lake.

Bufo lentiginosus Shaw. The ubiquitous toad was present, but not in great numbers at Syracuse, Turkey and Tippecanoe lakes.

Acris gryllus crepitans Baird. Abundant along the shallow margins of the lake among rushes and lillypads. Detailed localities where it was taken are outlet of String Lakes, Turkey Lake, Syracuse Lake, Turkey Creek, Webster and Tippecanoe Lakes and Tippecanoe River.

Rana virescens Kalm. Very abundant and variable. I am not at all certain that the varieties described by Cope and Hay are to be found among our material, but it seems quite certain that there is no correlation in the variations of different parts of the body. If varieties are to be distinguished it must be by separating them on single characters.

I have made measurements of a number of characters to determine whether the 120 specimens collected could be grouped according to any of these.

The relation of the tibia in the length of the body gave the length of the tibia .55 that of the body as the most common relation between the parts.

From this there is a gradual reduction to a length of .49 on the one hand and an increase to .70 on the other. But .20 of the specimens had the tibia with the most common length. This character is then perfectly useless in separating varieties in my specimens.

The same may be said of the length of the head in the length of the body, .33 is the relation occurring oftenest and from this there is a variation to .20 on one hand and .27 on the other; .20 of all the specimens have the length of the head .33 of the length of the body.

The relation of the fifth toe to the length of the third toe gave a very jagged curve with the length of the fifth toe .95 of the length of the third as the condition occurring in .20 of the specimens. From this a very irregular curve extends to .89 on one side and to 1.00 on the other.

The relation of the diameter of the tympanum to the diameter of the eye gave the most irregular curve. Thirty-five per cent. of all the specimens had a tympanum with a diameter equal to .60 of that of the eye. From this we have a saw-toothed curve to .48 on one side and .70 on the other. A comparatively large per cent.—15 per cent.—have a relation of .50. Attempts to get system out of this curve by breaking it up into age curves did not succeed entirely. But these separate curves for the different ages show that in the young the tympanum is comparatively small, and that the peak noted at the .50 mark is due to the young included in the general curve.

The whole study emphasized the fact that there is little or no coördination in the variation in this frog. No two characters, in fact, seem to vary together and all the specimens may be referred to but one variety.

I have in the following grouping, in the shape of the conventional key, separated the specimens according to their color patterns. All but one or two of the combination of patterns contains individuals which have the vomerine patches of teeth forming a straight line, and others with these patches inclined to each other at a more or less distinct angle. They clearly show that there is no coördination in the different parts of the color pattern. Each region varies apparently independently of the others.

KEY TO THE COLOR PATTERNS.

a. A spot on the nose.
- *b.* Two complete series of spots on the back.
  - *c.* Two cross bars on the femur.
    - *d.* Tibia with a mixture of spots and bars. 5 specimens.
- *bb.* Two complete series of spots on the back, with a third broken series between.
  - *e.* Two cross bars on the femur.
    - *f.* Tibia, with a mixture of spots and bars. 16 specimens.
    - *ff.* Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 1 specimen.
  - *ee.* Three cross bars on the femur.
    - *g.* Tibia, with a mixture of spots and bars.
      - *h.* Spots on back, many and small. 21 specimens.
      - *hh.* Spots on back, few and large. 13 specimens.

gg. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 9 specimens.

eee. Four or five cross bars on femur.

i. Tibia, with a mixture of spots and bars. 16 specimens.

ii. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 2 specimens.

aa. No spot on the nose.

j. Two series of spots on the back.

k. Two cross bars on femur. Tibia, with a mixture of spots and bars. 4 specimens.

kk. Three cross bars on the femur. Tibia, with a mixture of spots and bars. 4 specimens.

kkk. Irregular number of cross bars on femur, always more than three.

l. Tibia, with a mixture of spots and bars. 2 specimens.

ll. Tibia, with a row of spots on the anterior and posterior edge, upper surface unspotted. 2 specimens.

jj. Two complete series of spots on the back, with a third broken series between them.

m. Two cross bars on the femur. Tibia, with a mixture of spots and bars. 4 specimens.

mm. Three cross bars on the femur.

n. Tibia, with a mixture of spots and bars. 11 specimens.

nn. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 4 specimens.

mmm. Four or five cross bars on the femur.

o. Tibia, with a mixture of spots and bars. 1 specimen.

oo. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 4 specimens.

String Lakes, Upper and Lower Turkey Creeks, Turkey, Webster and Tippecanoe Lakes.

Rana palustris LeConte. One at the String Lakes, one at Turkey Lake, five at Tippecanoe Lake.

Rana sylvatica LeConte. A single specimen at Turkey Lake.

Rana clamata Daudin. Abundant at Upper and Lower Turkey Creek, Turkey and Tippecanoe Lakes.

Rana catesbiana Shaw. Abundant among lily pads, especially in parts of the lake not frequently visited. Turkey and Tippecanoe Lakes.

SNAKES OF TURKEY LAKE. BY G. REDDICK.

The number of specimens of snakes taken amount to about 225. They belong to five genera and eight species.

Bascanion constrictor Linn. is common around Turkey Lake and is the largest of the snakes found here. This snake is of course no part of the lake fauna. This snake was also taken at Lake Tippecanoe.

Eutainia sirtalis Linn. is very abundant along the margin of the lake, feeding on frogs and fish. One specimen was secured with a cat-fish spine sticking through the body wall of the snake.

Young taken from this snake July 17 averaged a slight fraction over seven inches in length and were almost grown, only a very small amount of the yolk being left. These young as soon as they were liberated would try to crawl away, and upon provocation and some without provocation would open their little mouths and flatten their heads and strike as viciously as old snakes.

As high as seventy-two young were taken from one snake, and often from thirty to forty. The average appearing to be between thirty and forty. This snake was also secured from Tippecanoe Lake.

Eutainia saurita Linn. is not nearly so abundant nor is it nearly so prolific. Eggs were taken from only three or four specimens, six being the highest number taken from any one. Spècimens of this snake were also taken from the margins of Lake Tippecanoe.

Eutainia butlerii Cope. Only one specimen of this was taken. It was fourteen and one-half inches long. This snake is short and chubby and its movement is very characteristic of it. It does not have the gliding movement of *E. saurita* nor the swift but yet very active movement of *N. sipedon*, but seems rather to exert a large amount of force to do little crawling. The movement is so characteristic that I believe any one, having once seen the peculiar way in which it tries to hurry itself away, would ever after be able to recognize it at a distance. No specimen was taken from Lake Tippecanoe.

Natrix leberis Linn. is rare in Turkey Lake, but common in Lake Tippecanoe. Twelve is the highest number of embryos taken from any one specimen.

Embryos taken August 5 contained a considerable amount of yolk; probably enough to nourish the embryo for a month or more.

Natrix sipedon Linn. is the most abundant of snakes found in this region, but not the most prolific, *E. sirtalis* standing ahead of it. Thirty-four was the highest number of eggs taken from any one specimen. One snake which was kept in confinement gave birth to fourteen young the third week of September.

Among the bullrushes is a favorite abode for this snake, and also under anything whatever that happens to be lying along the margin of the lake, especially if it happens to be lying partly in the water.

Sistrurus catinatus Raf. This snake is very common around Turkey Lake and also around Lake Tippecanoe. Several specimens were secured and others killed. It lives chiefly in the swamps.

A specimen taken August 6 contained five eggs and the embryos were seven inches long.

Storeria dekayi Holb. Only one specimen of this was secured. It was taken along a highway running by the side of a swamp.

Testudinata. By C. H. Eigenmann.

Turtles are at all times and everywhere abundant. They frequent especially the shallower portions of the lake. Many specimens of all ages were preserved. The number of variations in the shields is large. I present here simply a list with notes on their abundance and breeding habits.

Chelydra serpentina Linnaeus. This species is abundant in Turkey Lake, and reaches a larger size than any of the others. It is caught for the markets. It is much shyer than the other species of turtles and is not frequently seen. It inhabits the shallower muddy parts of the lake, being abundant in the kettle and about Morrison's Island. No eggs were found.

Trionyx spiniferus LeSueur. The soft-shelled turtle is very abundant. It is the second in size and is caught for the markets. Its round eggs are laid in the sand and gravel near the water's edge during June and July. On June 26 one was seen digging a nest in the gravel banks at Syracuse, and on the 27th we obtained eggs from five nests about Ogden Point and other places about the kettle. Other fresh nests were found July 9. The time of hatching was not determined.

Several empty nests were found in July, but some eggs, examined as late as September 1, contained young which would have been ready to hatch about a month later. The number of eggs found in several nests was as follows: 9; 12; 17; 18; 27; 32.

Aromochelys odorata Bosc. This species is abundant, but not conspicuous. Individuals were oftenest seen the latter part of June and first part of July while laying their eggs. The eggs are laid in the rotten wood in the tops of stumps standing in the margin of the lake. The turtles were frequently found in the tops of these stumps, and some of their eggs wedged as far into the rotten wood as a finger could bore. Rotten logs removed some distance from the water are also favorable places for egg laying, and in a mucky place of small area at the edge of the lake 362 eggs were taken at one time. The number of eggs laid by one individual varies from 4 to 7, this number being usually in a cluster. At this rate about sixty turtles must have contributed to the nest of 362. While passing along a wheat field some turtles were seen coming from it, and on inspection it was found that they had deposited their eggs in the ground in depressions made by a cow while walking over the ground when it was soft. Still other eggs were found in bundles of rushes drifted together. An interesting change of habit seems to have taken place among these turtles during the last fifty years. Before that time the number of stumps standing in the margin of the lake must have been exceedingly small. The present large number is due to the rising of the lake after the building of the dam and the subsequent cutting down of the trees whose boles had become submerged. The habit of laying eggs in stumps can not be of much more than fifty years' duration.

The time of laying must be scattered over considerable time, for many eggs were found hatched in August, while some obtained about then hatched at various times from September 15 to November 1. These were, however, kept in a box in a room and therefore removed from normal conditions. The age of this, as of all other hard-shelled turtles, can be estimated by the lines of growth on the horny cuticle. The originally exposed part of the plate occupies the mediocephalic corner of the plate and additions occur as smooth strips along the outer and posterior margins. The strips are quite distinct in early years, but become more or less obscure with age.

Chrysemys marginata Agassiz. This appears to be the most abundant turtle of the lake. How far its apparent abundance may be due to its habits I am unable to say. It is found floating or quietly paddling along, its head out of the water, but on nearer approach it always turns tail and seeks refuge in the abundant chara fields or in other hiding places. The chara fields are traversed by narrow paths

and tunnels made by this turtle. The eggs are laid later in the summer and farther from the water than those of the other species. Many were leaving the water in late August; the eggs were found but once.

Malaclemmys geographica LeSueur. Next to Chrysemys the most abundant of the turtles. It goes by the appropriate name of Housetop.

Emys blandingii Holbrook. Found in moderate numbers in the lake and along the banks of Turkey Creek.

Clemmys guttata Schneider. But two specimens were seen.

Cistudo carolina Linnæus. One specimen of this species was taken. It, however, in no sense forms a part of the fauna of the lake.

WATER BIRDS OF TURKEY LAKE. BY F. M. CHAMBERLAIN.

The following birds were taken between July 1 and September 1, on or near Turkey Lake. Only those of more or less aquatic habits are listed:

1. *Hydrochelidon nigra* L.
2. *Botaurus lentiginosus* Montaga.
3. *Botaurus exilis* Gmelin.
4. *Ardea virescens* L.
5. *Rallus elegans* Audubon.
6. *Rallus virginianus* L.
7. *Gallinula galeata* Lichtenstein.
8. *Fulica americana* Gmelin.
9. *Actitis macularia* L.
10. *Aegilites vocifera* L.
11. *Ceryle alcyon* L.
12. *Agelaius phoenicus* L.
13. *Clivicola riparia* L.
14. *Cistothorus palustris* Wilson.

PART III—VARIATION.

The Study of Variation.* By C. H. Eigenmann.

Variation and Its Importance. No two individuals are exactly alike. The differences of whatever sort, whether in structure or habit, between the individuals of a species, whether these individuals are related to each other as parent and child, or belong to the same brood, are termed variation.

The whole basis of the Darwinian idea of evolution is this individual variation. At present we have two estimates of the importance of individual variation.

I. The individual variations are of the utmost importance, and all species are the result of natural selection working on the varying individuals of any species.

II. Individual "variation offers us little hope of learning the real facts of evolution," "species are not the result of the selection of a few favorable variations out of a large number of haphazard changes," but to "the orderly advance (of the mean specific form) towards the final goal, deviating very little from the direct line."†

We subscribe to neither of these views, wishing to view the facts as they are presented by the conditions of the environment at Turkey Lake and the lakes in the neighborhood, in a perfectly impartial way.

The causes of variation are still unknown, though several explanations have been attempted. This is not surprising since the variations in no species are sufficiently known to formulate any satisfactory explanation, in fact little has been attempted but to determine the extent of variation in comparatively few cases where the variation is great, resulting in the naming of new varieties and in the recording of abnormalities. The statistical method of studying variation is of the most recent date, but much promises to be done with this method.

Distribution of Variations. Variations are to be found at all times and at all places where organisms exist. They are found under conditions where the environment is in a state of stability. The conditions under which the greatest variability is found (in fishes) are:

1. Wide distribution. A large territory is, usually, though not necessarily, inhabited by more or less stable varieties.

*Contributions from the Zoölogical Laboratory of the Indiana University, No. 17.

†This wording is from Scott, but since the paragraphs are selected from isolated parts of his paper, I do not wish to convey the idea that they state his views as he would like to have them stated. The paragraphs state an extreme view.

2. Great physical and climatic differences, even in comparatively narrow limits. No more striking illustration can be imagined than is offered by the streams of the Pacific slope of North America, which are inhabited by extraordinary variable species, without stable varieties

3. Amphimyxis has been suggested by Ayres as a condition favoring the display of great variation.

These are simply statements under which variation seems to find its optimum condition and do not approach any explanation of its causes.

CLASSIFICATIONS OF VARIATIONS.—Students of variation have found it advantageous to analyze the phenomena, and the result of this analysis has given us the following classifications:

Continuous variation, including all gradual modifications and transitions.

Discontinuous variation; any sudden and wide modifications or saltations.

Using other features as the basis of classification, we have:

Meristic variations dealing with the change in the number of successive parts.

Substantative dealing with the chemical modifications of parts.

Another classification gives us:

Indeterminate, or fortuitous and aimless variation. This is largely individual and pertains to series of variations either geographically or geologically.

Determinate and adaptive, leading to definite end.

The most essential and at the same time the most difficult to define is the distinction between—

Ontogenetic variation including all those deviations appearing at any time, from any cause, during the life cycle of an individual;

Phylogenetic variations change from the specific characters appearing at some time in the life cycle of an individual, or better still, a large number of individuals, reappearing in the next generation, finally becoming hereditarily fixed.

I have in the following directions omitted the use of the terms ontogenetic and phylogenetic. Recently (Osborn, 1894, the distinction between ontogenetic and phylogenetic variation in the study of evolution has been strenuously insisted upon as the only possible way of determining the value of any given variation in the process of evolution. However, it is certainly impossible in many cases to determine whether a given variation is ontogenetic or phylogenetic as defined by Osborn. To give a concrete case. The ancon sheep of evolutionary classics was born with short legs. Were they ontogenetic or phylogenetic? Subsequent events proved that they were phylogenetic, but certainly the short legs in themselves enabled no one to make the distinction; the hereditary transmission decided the

matter. Sports, therefore, of which the ancon sheep was certainly one, may be phylogenetic. Scott, however, has recently shown, Am. J. Science, 369, 1894, that many if not most saltatory variations are of an entirely different nature from the variations that in the past have given rise to phylogenetic series. In a deviation much less marked, such for instance as the presence of one more than the normal number of spines in a fin, this ultimate criterion of transmission might fail us even were it practicable to put it to the test. A surer way of determining phylogenetic variation is to measure variation in the bulk by means of curves. If, say one thousand individuals of a definite time and place, show in the aggregate a character different from that normal to the species, it is phylogenetic. Such variations may occur in successive years or at isolated places. The phylogenetic character is in such a case really made up of a large number of ontogenetic variations which must also be capable of reappearing; that is, they must also be phylogenetic. A better way of stating the problem would seem to me to be that:

All variations are ontogenetic, some are at the same time immediately phylogenetic and many if not all may become so—a phyletic series. This leaves open the question of the conditions under which ontogenetic variation becomes phylogenetic and ignores the unchanged germplasm theory which from purely embryological grounds is untenable.

The paragraphs pertaining to this subject in the following direction are: 7. 8, 13, 15, 16.

Nearly synonymous terms with ontogenetic and phylogenetic are the terms variation and mutation as used by Newmayr, Waagen, and Scott. Variation is here applied to locally different forms, while mutation is applied to the chronological changes or "steady advance (of the mean) along certain definite lines" The latter term may for our purpose be still further restricted by applying it not only to the changes of the mean in successive geologic periods, but to the changes in the mean which may occur in two successive years or broods.

To quote Newmayr, pp. 60-61 (from Scott, p. 372), "Weil ein Theil der Merkmale gleichmässig nach einer Richtung im Laufe der Zeit mutirt, zeigen andere Charactere regellose Abänderungen und jede Mutation entwickelt denselben Varietätenkreis." Scott illustrates this process by comparing the mutation to the progress of a cyclone center and the continual circlet of variations to the circulating winds.

DETAILED DIRECTIONS FOR COLLECTING AND STUDYING SPECIMENS.

The following directions and explanations have been prepared for the students at the Biological Station for the study of the variation of the inhabitants of lakes Turkey and Tippecanoe and the small lakelets in the neighborhood.

1. Collect at random all available specimens, to the number of several hundred, the last week in June, in both Turkey and Tippecanoe lakes, keeping the exact location where each lot of specimens was collected.

It is necessary to collect at random or the personal element of the collector may become a disturbing factor in determining the variation. The date, which is not necessarily fixed for any particular week, has been selected because at this time many very young specimens, but a few weeks old, can be secured. It is necessary to collect in both lakes at approximately the same date in order to secure corresponding ages.

2. Collect in the same manner and an equal number of specimens in each lake near the end of August.

From this second collection the rate of growth and any elimination taking place early in life may be determined.

3. Arrange the material of each date according to the size, to determine whether the broods of successive years can be separated.

If specimens have been collected at random and include all sizes this can usually be done for the preceding few years. Among the older individuals the gradation in size is usually too perfect to permit any grouping according to age.

4. Determine the variation in two or more prominent characters in each brood of specimens, keeping the record and labeling the specimens in such a way that the specimen for any record can at any time be re-examined. Determine at the same time the sex.

This is by far the most laborious and time killing operation, but absolutely essential to determine anything further. The characters measured in fishes can always be the number of rays in the dorsal and anal fins, and the number of scales in the lateral line. Other characters will vary with the species, as one species has one, another a different character that lends itself especially to the study of variation. In reptiles deviations in the number and characters of plates are available characters for the study of variation. Of course any character can be taken, but one in which the variation can be numerically expressed and the number be determined by a simple count instead of a measurement, is vastly superior, since nothing can be left to the judgment, and the personal element is therefore much less important.

5. Are there external sexual differences, and is the amount and extent of variation different in the sexes?

This determination can usually be left till later; it is introducèd here so as not to mar the sequence of the following points.

6. Is there a successive modification in going from younger to older specimens indicating a structural modification with age?

It may be possible with some species, for instance, that the number of rays increases directly with the age. Should such a case exist it might give rise to entirely erroneous notions as to the influence or effect of selective destruction.

7. Is the variation of each year grouped about a mean common to all the specimens, or is each year's variation grouped about a center of its own?

While the idea of the annual variation or the reaction of each brood to a slightly varying environment was supposed to be a possible element, and suggested as such in my first announcement of the station, I was entirely unprepared for the startling annual variation in such a prominent character as the number of dorsal spines which has been discovered by Mr. Moenkhaus and reported upon in another paper.

The neglect of the consideration of the environment during the early period of development in modifying successive broods in different ways may lead to entirely erroneous ideas of the structural modifications of growth on the one hand, or the entirely erroneous ideas of the action of selective destruction on the other. To determine the latter it is absolutely necessary to take individuals of the same year's broods at successive periods or successive years. Whether as great an annual fluctuation is present in crabs as has been observed in Etheostoma I can not presume to say. But the entire neglect of this element vitiates the results of Prof. Weldon, of the committee of the royal society for "Conducting statistical inquiries into the measurable characteristics of plants and animals," which Mr. Thistelton-Dyer (Nature, Mch., 1895) considers to be "among the most remarkable achievements in connection with the theory of evolution."

I quote from Prof. Weldon to show his methods and results. (Nature, Mch. 7, 1895, p. 449.) "In order to estimate the effect of small variations upon the chance of survival, in a given species, it is necessary to measure, *first*, the percentage of young animals exhibiting this variation; *secondly*, the percentage of adults in which it is present. If the percentage of adults exhibiting the variation is less than the percentage of young, then a certain percentage of young animals has either lost the character during growth, or has been destroyed. The law of growth having been ascertained, the rate of destruction may be measured, and in this way an estimate of the advantage or disadvantage of a variation may he obtained.

In order to estimate the effect of deviations of one organ upon the rest of the body, it is necessary to measure the average character of the rest of the body in individuals with varying magnitude of the given organ."

Conclusions reached by an application of these principles to a study of the shore crab gave as a result that—*a*. There is a period of growth during which the frequency of deviations increases. *b*. That in one case the preliminary increase is followed by a decrease in the frequency of given magnitude, in the other case it was not. *c*. Assuming a particular law of growth the observations show a selective destruction in the one case and not in the other.

8. What is the relation of the annual fluctuation (mutation) in variation to the annual fluctuation in the different elements of the environments?

9. What is the difference in the variation of the youngest brood early in the season and late in the season, and what is the difference in the variation in succeeding years of the same brood? Is this difference, if any exists, due to modifications with age or to selective destruction, *i. e.*, has a larger percentage of individuals with one characteristic been eliminated than of individuals with this characteristic slightly different? In what part of the curve of variation have the greatest changes been produced?

10. If certain individuals with definite characters seem to survive, can it be determined in what way this variation brings about the survival?

11. At what age or stage of growth are variations greatest?

12. Can variations arising with age be referred to habits or environment?

13. What is the relation of sports or saltatory variations to the continuous variation numerically?

By saltatory variations are meant all those variations not connected with the mean by intermediate steps.

14. Are saltatory characters always bilateral? If not, to what degree are they bilateral?

The fact that a saltatory variation is confined to one side or is found on both sides, may enable us to determine whether the deviation began in the germ before the appearance of bilaterality or is of later origin.

15. In how far is the repetition of a character due to the repetition of the environment as shown in the correlation of annual fluctuations in environment with annual variations? See under 8.

Whitman Biological Lectures, 1894, p. 4: "An epidemic of metaphysical physics seems to be in progress—a sort of *neo-epigenesis*. In place of the *vis essentialis* of the old epigenesis, the new epigenesis sets up as its fetich the *vis impressa*. The new god is preferred because it works from the outside instead of

the inside. It represents the sum of external conditions and influences at the present moment, and is proclaimed all-sufficient for building up organisms out of isotropic corpuscles. Previous conditions are not, indeed, quite ignored, for they have resulted in special molecular constitutions called germs, and these display molecular activities known as metabolism, growth and division. The long past can bring forth only a molecular basis; a few hours of the present can supply all, or nearly all, the determinations of the most complex organism. Impotent past; prepotent present. We have no longer any use for the 'Ahnengallerie' of phylogeny. Heredity does not explain itself or anything else, and it detracts from the omnipotence and universality of molecular epigenetics. We are no better off for knowing that we have eyes because our ancestors had eyes. If our eyes resemble theirs it is not on account of geneological connection, but because the molecular germinal basis is developed under similar conditions. The reason this basis becomes an eye rather than an ear or some other organ is wholly due to its position and surroundings, not to any inherent predeterminations. If the material for the eye and the ear could be interchanged in the molecular germ, that which in one place would become eye would in the other place become ear, and *vice versa*."

16. In what characters does the same species in the neighboring lakes differ, and in what respects does the variation differ in the different lakes?

17. Are variations in one part of the body correlated with variations in another part of the body?

In many cases this can only be determined by converting the variations in part into the terms of the variation of another part. The method for doing this has been suggested by Galton, whose method is discussed at the end of this paper.

18. What correlation is there in the variation of different species under the same environment?

As far as I am aware, no systematic studies of this description have been made. With us this study resolves itself into the determination of whether the fishes in Turkey Lake all differ from those in Tippecanoe along definite, determined ways, so that given the characters of a species for Turkey Lake the characters for the same species in Tippecanoe could be predicted.

Similar but exotic instances are the absence of ventral fins in some of the fishes inhabiting even widely separated mountain lakes, and the presence of enlarged scales along the base of the anal in the Cyprinidæ inhabiting mountain streams of India; or, to come nearer home, the peculiar color patterns of the fishes in some regions of upper Georgia.

Method of Presenting Results. Results of statistical inquiries into variation can best be presented by frequency of error curves, and these will be used wherever possible. The abscissa will in all cases be made to represent the size of the organ, the ordinate the percentum of individuals having the particular size.

To convert variations in one organ into the terms of another organ the scheme of distribution will be used with the formula given by Galton for comparing one such curve with another. The process of comparing any curve "a" with any curve "b," multiply each of "a's" height by $\frac{\text{Q of "a"}}{\text{Q of "b"}}$. The Q of any scheme of distribution is one-half the difference between any two grades. The same grades in the two curves to be compared being used to determine their Q for this purpose, 25 per cent. and 75 per cent. are suggested as most convenient by Galton.

Ideally the variations occurring in a single organ expressed by a frequency of error curve, when a large number of individuals have been examined, will form a symmetrical curve which is called a "normal." Such a curve may always be expected when the material under consideration is of a single origin and has developed under the same environment. Unfortunately for non-mathematical evolutionists, the converse does not seem to be the case, for a symmetric curve may be made up of two symmetric curves with axes not far apart, a fact that can only be determined mathematically. Says Pearson, "There will always be the problem: Is the material homogeneous and a true evolution going on, or is the material a mixture? To throw the solution on the eye in examining the graphical results is, I feel certain, quite futile."

It is not hoped that the data can be treated with the mathematical refinement suggested by Pearson, nor is it probable that such treatment of our material will become absolutely necessary, since there can be but little question of the unity of origin of the material in any given small lake.

While usually, as stated above, the curve resulting from the study of a large number of specimens will be symmetric, it will frequently be asymmetric. Samples of the different sort of curves actually observed are given.

Asymmetric curves may be the result,

1. Of the selective influence working on one side of a symmetric curve and be then found in more or less mature specimens.

2. Of the reaction to a change in the environment and indicative of a mutation or change in the mean specific form.

3. Of the double origin of the material under consideration, and may then have a great variety of forms, from slightly asymmetric curve to one with a broad top or with many peaks.

RECENT LITERATURE ON HEREDITY AND VARIATION.

For the older literature, see Davenport, '95, Keeler, '93, Osborn, '94, and Thomson, of the following list:

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VARIATION OF NORTH AMERICAN FISHES. II.

THE VARIATION OF ETHEOSTOMA CAPRODES RAFINESQUE IN TURKEY LAKE AND TIPPECANOE LAKE.* BY W. J. MOENKHAUS.

INTRODUCTION.—In a former paper on the "Variation of *Etheostoma caprodes* Rafinesque" (Am. Nat., Aug., 1894), I determined the geographical distribution of this fish and the geographical variation of its color-pattern and fins.

It was found that this species inhabits practically all the fresh waters of the Atlantic slope east of the 100th meridian and west of the Alleghany Mountains. Its northern and eastern limits are the Great Lakes and Lake Champlain; its southwestern, the Rio Grande in the extreme southern part of Texas.

The following conclusions were reached among others:

1. Each river system from which specimens were examined possesses a peculiar variety. This peculiarity is most striking in the color-pattern.

2. All the variations are continuous.

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*Contributions from the Zoölogical Laboratory of the Indiana University under the direction of C. H. Eigenmann, No. 18.

3. The variation in the anal rays and dorsal spines are determinate with the latitude, the southern specimens having a slightly larger number of rays and spines.

4. The color-pattern variations are determinate, varying through definite stages from a simple to more complex pattern.

In Table A and B are given the data on the anal rays and dorsal spines. The localities are arranged in the order of their latitude from north to south. From these we see that there is both an increase in the average number of rays and spines and in the number that prevails in each case from north to south. In the anal fin 10 is the prevailing number north, and 11 and 12 south, of the Ohio River. Fourteen and fifteen are the prevailing number of dorsal spines in the north and 15, 16 and 17 in the south.

TABLE A.

LOCALITY.	Number of Specimens.	Average Number of Anal Rays.	Number of Specimens with 10 Rays.	Number of Specimens with 11 Rays.	Number of Specimens with 12 Rays.
Torch Lake, Mich	7	$10\frac{1}{7}$	6	1	......
Cedar Rapids, Iowa	1	12	......	......	1
White River, at Indianapolis	1	10	1	......	......
Gosport, Ind	5	10	5	......	......
Bean Blossom, Ind	17	$10\frac{9}{17}$	8	9	......
Rushville, Ind	1	10	1	......	......
Wild Cat Creek, Ind	1	11	......	1	......
Pike Creek, Ind	2	11	......	2	......
Illinois	1	10	1	......	......
Nipisink Lake, Ill	2	$10\frac{1}{2}$	1	1	......
Monongahela River	1	10	1	......	......
Hartford, Ky	4	$10\frac{1}{4}$	3	1	......
Green River, Greensburg, Ky	3	$10\frac{2}{3}$	1	2	......
Little Barren River, Osceola, Ky	4	11	......	4	......
Little South Fork Cumberland River, Wayne County, Ky	1	11	......	1	......
Eagle Creek, Olympus, Tenn	2	11	......	2	......
Obeys River, Elizabethtown, Tenn	13	$11\frac{6}{13}$	1	5	7
Watauga River, Elizabethtown, Tenn	2	$10\frac{1}{2}$	1	1	......
North Fork Holston River, Saltville, Va	1	12	......	......	1
Eureka Springs, Ark	1	......	......	......	......
Chocola Creek, Oxford, Ala	4	$11\frac{1}{4}$	......	3	1
San Marcos Springs, Tex	2	11	......	2	......

TABLE B.

LOCALITY.	Number of Specimens.	Average Number of Dorsal Spines.	Number of Specimens with 13 Rays.	Number of Specimens with 14 Rays.	Number of Specimens with 15 Rays.	Number of Specimens with 16 Rays.	Number of Specimens with 17 Rays.
Torch Lake, Mich	7	14$\frac{4}{7}$		3	4		
Cedar Rapids, Iowa	1	14		1			
White River, at Indianapolis	1	14		1			
Gosport, Ind	5	14[illegible]		1	4		
Bean Blossom, Ind	17	14$\frac{7}{17}$	1	9	7		
Rushville, Ind	1	14		1			
Wild Cat Creek, Ind	1	15			1		
Pike Creek, Ind	2	14$\frac{1}{2}$		1	1		
Illinois	1	15			1		
Nipinsik Lake, Ill	2	14$\frac{1}{2}$		1	1		
Monongahela River	1	15			1		
Hartford, Ky	4	15		1	2	1	
Green River, Greensburg, Ky	3	15			3		
Little Barren River, Osceola, Ky	4	15		1	2	1	
Little South Fork Cumberland River, Wayne County, Ky	1	16				1	
Eagle Creek, Olympus, Tenn	2	16$\frac{1}{2}$				1	1
Obeys River, Elizabethtown, Tenn	13	16[illegible]			2	3	8
Watauga River, Elizabethtown, Tenn	2	15$\frac{1}{2}$			1	1	
North Fork Holston River, Saltville, Va	1	16				1	
Eureka Springs, Ark	1	16				1	
Chocola Creek, Oxford, Ala	4	15$\frac{1}{2}$			2	2	
San Marcos Springs, Tex	2	13$\frac{1}{2}$	1	1			

The color-pattern varies from a probably primitive, simple pattern consisting of alternate whole and half cross-bars distributed along the entire length of the body through the pattern consisting of whole, half and quarter bars, having an incomplete longitudinal series of lateral spots to a pattern having a very prominent longitudinal series of dark lateral blotches with fine reticulations on the back. Between these different patterns all stages exist, so that they can be connected by regular steps. Those specimens inhabiting the lakes were found to possess a peculiar color-pattern. This was derived from the primitive, simple pattern by supposing the lower part of the whole bars to have become much broader than the upper part, and then to have shifted backwards slightly.

This lake variety (*manitou*, Jordan) is one of the most abundant of the fishes in Turkey and Tippecanoe Lakes, and upon it the results given in the following pages are based.

Six hundred specimens, all that were collected from Turkey Lake, and three hundred of those collected from Tippecanoe Lake, have been examined with a view, first, of making a comparison of this species in the two lakes, and second, of determining the range and character of its variation within Turkey Lake itself. The number of species collected from Tippecanoe Lake is much greater than 300, but this number was thought sufficient to give fairly good results. The effect of natural selection will be taken up at a later time.

Etheostoma caprodes has two dorsal fins, the first, a spinous one, well separated from the second, which is composed of soft rays. The anal fin is composed of two rather strong spines followed by a number of soft rays. The scales are very regularly arranged, so that they can be definitely counted along the complete lateral lines. The number of spines and rays in these fins, and the number of scales in the lateral line of both sides of the body have been determined. Besides these characters the presence or absence of scales on the nape has been determined. These structures have been taken because, with the exception of the last, they present definite, countable elements, so that in the results the personal factor is entirely eliminated.

Curves have been constructed to represent the variation in these structures. In all the curves the horizontal distances represent the countable elements, and the vertical distances the per cent. of specimens possessing these varying elements.

COMPARISON OF TURKEY LAKE AND TIPPECANOE SPECIMENS.

COLORATION.—The coloration of these fishes in the two lakes will be taken up in detail later. The color-pattern of Turkey Lake specimens is, on the whole, of a more blotched character than that of Tippecanoe Lake specimens, and shows a slighter affinity to the simple, primitive coloration characteristic of the Wabash River forms. The connection of Tippecanoe Lake with the Wabash River may account for this greater affinity.

SQUAMATION OF NAPE.—In Turkey Lake the nape is as a rule naked, while in Tippecanoe Lake it is usually scaled. Table I will bring out the difference.

TABLE I.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having no scales on nape	88.00	19.32
Per cent of specimens having few scales on nape	8.00	23.87
Per cent. of specimens having several scales on nape	4.00	28.32
Per cent. of specimens having nape thinly scaled............	0.20	16.67
Per cent. of specimens having nape closely scaled.........	0.00	11.74

LATERAL LINE.—The specimens of Turkey Lake have on an average two more scales in the lateral line. The average number for Turkey Lake is 89.46 for the left side, 89.74 for the right side; for Tippecanoe Lake, 87.69 for the left side, 87.45 for the right side. Fig. 1 represents the curves for the scales of the right side. The continuous line represents the conditions in Turkey Lake, and the broken line those of Tippecanoe Lake. It should be noticed that the entire curve for Turkey Lake is two units to the right of that of Tippecanoe Lake, showing that practically all the Turkey Lake specimens have a greater number of scales. Table II contains the summary of the counts for the scales in the lateral line.

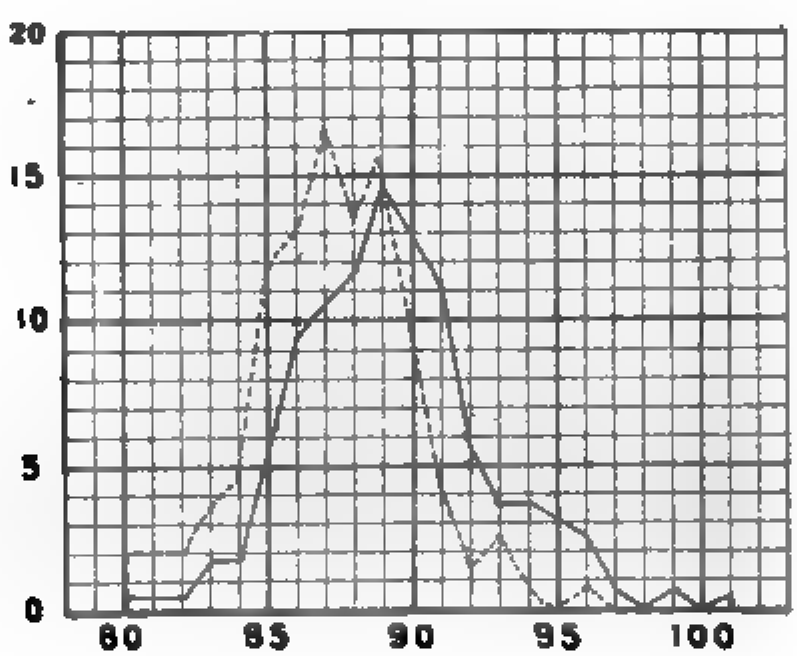

FIG. 1.

TABLE II.

	Turkey Lake.		Tipp'canoe Lake.	
	Left Side.	Right Side.	Left Side.	Right Side.
Per cent. of specimens having 78 scales....	0.17	....	....	....
Per cent. of specimens having 79 scales....	....	....	....	....
Per cent. of specimens having 80 scales....	0.17	0.34	....	....
Per cent. of specimens having 81 scales....	....	0.34	0.50	....
Per cent. of specimens having 82 scales....	0.17	0.34	1.00	2.00
Per cent. of specimens having 83 scales....	1.37	1.55	2.50	3.50
Per cent. of specimens having 84 scales....	3.44	1.89	7.00	4.50
Per cent. of specimens having 85 scales....	3.78	5.17	8.50	11.50
Per cent. of specimens having 86 scales....	6.88	9.30	11.50	13.00
Per cent. of specimens having 87 scales....	11.02	10.68	15.00	16.50
Per cent. of specimens having 88 scales....	12.56	11.55	15.00	13.50
Per cent. of specimens having 89 scales....	17.72	14.82	16.00	16.00
Per cent. of specimens having 90 scales....	12.39	12.93	11.50	10.50
Per cent. of specimens having 91 scales....	8.08	11.03	7.50	4.00
Per cent. of specimens having 92 scales....	6.53	5.67	1.50	1.50
Per cent. of specimens having 93 scales....	5.16	3.62	1.00	2.50
Per cent. of specimens having 94 scales....	3.61	3.78	0.50	0.50
Per cent. of specimens having 95 scales....	2.58	3.27	0.50	....
Per cent. of specimens having 96 scales....	1.37	2.41	0.50	0.50
Per cent. of specimens having 97 scales....	1.03	0.51	....	....
Per cent. of specimens having 98 scales....	0.17	....	....	....
Per cent. of specimens having 99 scales....	0.34	0.34	....	....
Per cent. of specimens having 100 scales....	....	....	....	....
Per cent. of specimens having 101 scales....	0.17	0.17	....	....
Per cent. of specimens having 102 scales....	0.17	....	....	....
Per cent. of specimens having 103 scales....	0.17	....	....	....

Anal fin.—The number of spines in the anal fin varies from the normal in only nine specimens from Turkey Lake and in six from Tippecanoe Lake. This variation is always toward a lower number, and extends only through one spine.

Turkey Lake specimens have on an average fewer rays in the anal than Tippecanoe Lake specimens. The averages are 10.87 for the former, 11.15 for the latter. Fig. 2 represents the curves for the anal rays. Here again, and also in the succeeding curves for the comparison of the two lakes, the continuous line represents Turkey Lake and the broken line Tippecanoe Lake. Table III gives the summary of the anal rays for both lakes.

The prevailing number of rays in both lakes is 11; 53 per cent. from Turkey lake, and 56 per cent. from Tippecanoe Lake having that number. The number of rays in the next highest per cent. is 10 for Turkey Lake and 12 for Tippecanoe Lake, about 27 per cent. in each case.

The range of variation is two greater in Turkey Lake. This may be due t the greater number of specimens from this lake.

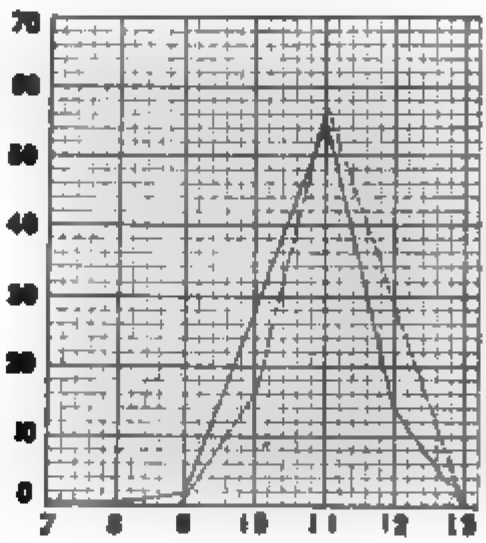

Fig. 2.

TABLE III.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 7 anal rays	0.16	......
Per cent. of specimens having 8 anal rays	0.16	......
Per cent. of specimens having 9 anal rays	1.48	0.77
Per cent. of specimens having 10 anal rays	26.80	15.50
Per cent. of specimens having 11 anal rays	53.43	56.21
Per cent. of specimens having 12 anal rays	14.13	27.13
Per cent. of specimens having 13 anal rays	0.49	0.35

Dorsal Spines.—Turkey Lake has on an average more dorsal spines, the average being 14.52 for Turkey Lake and 14.23 for Tippecanoe Lakes. Fig. 3 represents the curves for this structure. The range of variation is the same, from 12 to 17. Although the average number of spines differs but slightly in the two

lakes, the preferences shown for a given number of spines are quite different. In the Tippecanoe Lake specimens the preference is decidedly for 14. In the Turkey Lake specimens the preference is for 15, although not so decided. From Table IV and the curves, it will be seen that the number of individuals in Turkey Lake having 14 spines and 15 spines are about the same, 41 per cent. having 14 and 44 per cent., 15, while in Tippecanoe Lake this is not the case, 60 per cent. having 14, and only 25 per cent. having 15.

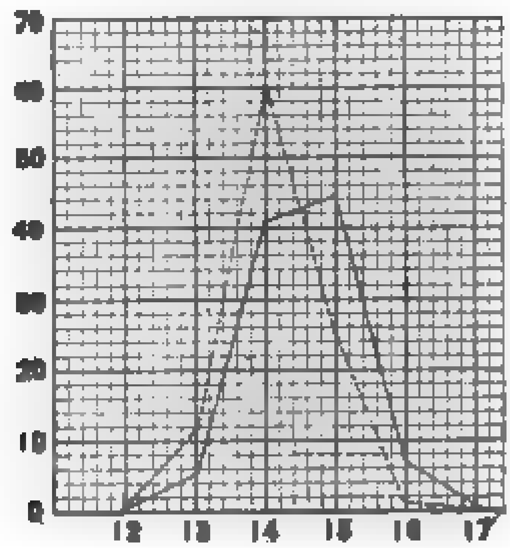

Fig. 3.

TABLE IV.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 12 dorsal spines............ ...	0.32	0.38
Per cent. of specimens having 13 dorsal spines...............	5.09	11.24
Per cent. of specimens having 14 dorsal spines....... .	41.26	60.85
Per cent. of specimens having 15 dorsal spines....	44.22	25.96
Per cent. of specimens having 16 dorsal spines...............	6.90	1.16
Per cent. of specimens having 17 dorsal spines...............	0.65	0.38

Dorsal Rays.—The average number of dorsal rays for Turkey Lake is 14.87, for Tippecanoe Lake, 16.40, the latter having on an average almost two more. The curves are given in Fig. 4. From this and Table V it will be seen that Turkey Lake specimens show a decided preference for 15 rays, while the Tippecanoe Lake specimens show just as decided a preference for 16 rays, 52 per cent. of the

specimens having these numbers in both lakes. The range of variation is two greater in Turkey Lake, from 12 to 18 as compared from 14 to 18 in Tippecanoe Lake. This again may be due to the greater number of specimens.

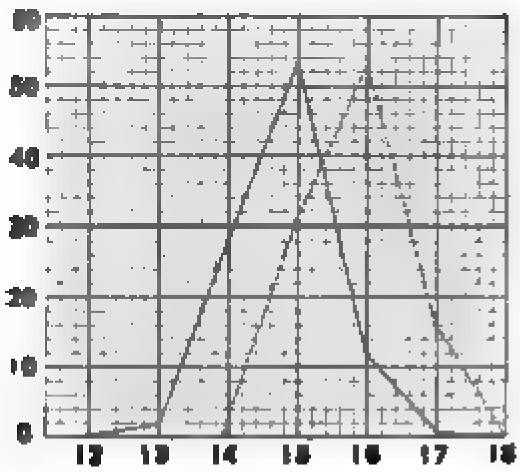

FIG. 4

TABLE V.

	From Turkey Lake	From Tippecanoe Lake.
Per cent. of specimens having 12 dorsal rays	0.32	......
Per cent. of specimens having 13 dorsal rays	1.48	......
Per cent. of specimens having 14 dorsal rays	28.77	3.48
Per cent. of specimens having 15 dorsal rays	52.26	31.78
Per cent. of specimens having 16 dorsal rays	12.16	52.32
Per cent. of specimens having 17 dorsal rays	1.64	15.11
Per cent. of specimens having 18 dorsal rays	0.16	0.77

Table VI presents all the combinations of dorsal spines and dorsal rays from both lakes. The spines are represented by Roman numbers and the rays by Arabic numbers. The commonest combination in Turkey Lake is XIV–15 and XV–15; XIV, XV, occurring most frequently in the spinous dorsal, and 15 most frequently in the soft dorsal. The per cent. of specimens having these combinations is 22.46 and 24.49 respectively. In Tippecanoe Lake, XIV–16 is the commonest combination, XIV being the prevailing number in the spinous dorsal and 16 in the soft dorsal. 32.11 per cent. of the specimens have this combination.

TABLE VI.

		From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having the combination	XII–14.....	0.16	....
Per cent. of specimens having the combination	XII–15.....	0.16	....
Per cent. of specimens having the combination	XII–16.....	....	0.37
Per cent. of specimens having the combination	XIII–14.....	0.84	0.37
Per cent. of specimens having the combination	XIII–15.....	3.71	2.22
Per cent. of specimens having the combination	XIII–16.....	0.67	5.92
Per cent. of specimens having the combination	XIII–17.....	....	2.59
Per cent. of specimens having the combination	XIV–12.....	0.16	....
Per cent. of specimens having the combination	XIV–13.....	1.01	....
Per cent. of specimens having the combination	XIV–14.....	11.99	1.48
Per cent. of specimens having the combination	XIV–15.....	**22.46**	20.37
Per cent. of specimens having the combination	XIV–16.....	5.74	**32.11**
Per cent. of specimens having the combination	XIV–17.....	0.33	6.66
Per cent. of specimens having the combination	XIV–18.....	....	1.11
Per cent. of specimens having the combination	XV–13.....	0.67	....
Per cent. of specimens having the combination	XV–14.....	13.51	1.85
Per cent. of specimens having the combination	XV–15.....	**24.49**	8.14
Per cent. of specimens having the combination	XV–16.....	5.40	14.44
Per cent. of specimens having the combination	XV–17.....	0.84	1.48
Per cent. of specimens having the combination	XV–18.....	0.16	....
Per cent. of specimens having the combination	XVI–12.....	0.16	....
Per cent. of specimens having the combination	XVI–13.....	0.16	....
Per cent. of specimens having the combination	XVI–14.....	2.36	....
Per cent. of specimens having the combination	XVI–15.....	3.04	1.11
Per cent. of specimens having the combination	XVI–16.....	0.84	0.37
Per cent. of specimens having the combination	XVI–17.....	0.33	....
Per cent. of specimens having the combination	XVII–14.....	0.50	....
Per cent. of specimens having the combination	XVII–15.....	....	0.37
Per cent. of specimens having the combination	XVII–16.....	0.16	....
Per cent. of specimens having the combination	XVIII–14.....	0.16	....

In Table VII is given the variation in the two dorsal fins taken together. The average number for the two fins is 29.21 for Turkey Lake and 30 for Tippecanoe Lake. In Turkey Lake 36.82 per cent. have the average number; in Tippecanoe Lake, 41.8 per cent. The range of variation in the fins separately is six for the spinous dorsal and five for the soft dorsal in Tippecanoe Lake, and seven in each dorsal fin in Turkey Lake. With an exception in the spinous dorsal in Tippecanoe Lake the range of variation is, in each case, one greater for the two fins taken together, than for the fins separately. Although the extent of variation is only one greater for the two fins together, the per cent. of specimens having the average number is much smaller than the per cent. of specimens having the average

number in the fins separately. In Turkey Lake nearly 37 per cent. have the average number of the fins taken together, while 44 per cent. and 52 per cent. have the average number in the spinous and soft dorsal respectively. In Tippecanoe Lake 41 per cent. have the average number for both fins, while 52 per cent. and 61 per cent. have the average number in the spinous and soft dorsals respectively.

TABLE VII.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 26 rays in the dorsals	0.33	....
Per cent. of specimens having 27 rays in the dorsals	2.02	0.37
Per cent. of specimens having 28 rays in the dorsals	16.38	4.07
Per cent. of specimens having 29 rays in the dorsals	36.82	28.15
Per cent. of specimens having 30 rays in the dorsals	32.59	41.80
Per cent. of specimens having 31 rays in the dorsals	9.28	22.22
Per cent. of specimens having 32 rays in the dorsals	1.85	3.33
Per cent. of specimens having 33 rays in the dorsals	0.67	....

SUMMARY.

1. This species is equally abundant in the two lakes.

2. The color pattern of Tippecanoe Lake specimens shows a greater affinity for the primitive, simple Wabash River pattern than does that of Turkey Lake specimens.

3. In Turkey Lake the nape is usually naked; in Tippecanoe Lake the nape is usually scaled.

4. Tippecanoe Lake specimens have a smaller number of scales in the lateral line.

5. The anal spines vary but little, and show the same variation in the two lakes.

6. The anal fin is somewhat larger in the Tippecanoe Lake specimens.

7. Turkey Lake specimens have one more dorsal spine.

8. Tippecanoe Lake specimens have one more dorsal ray, 16 rays is the mean in Tippecanoe Lake and 15 in Turkey Lake.

9. The combinations of the dorsal spines and rays are determined by the numbers that prevail in the fins separately.

10. The range of variation in the total number of dorsal spines and rays combined is one greater than the variation in the fins separately.

11. The number occurring most frequently is 29 in Turkey Lake and 30 in Tippecanoe Lake.

12. The preference shown for a given number is less decided for the two dorsal fins taken together than for the dorsal fins taken separately.

13. The variation is in all cases continuous.

THE VARIATION IN TURKEY LAKE.

Many of the facts on the extent and character of the variation of the 600 specimens from Turkey Lake, taken as a whole, have been given in the preceeding.

The lengths of the 600 specimens from Turkey Lake were measured and upon comparison were found to fall into three quite distinct groups. Fig. 5 represents the curve for all. Each of the smaller horizontal distances represents one mm. and each of the larger verticle distances one per cent The sizes ranged from 27 mm. to 102 mm. The first group ranges from 27 mm. to 60 mm.; the second from 60 mm. to 80 mm., and the third from 79 mm. to 103 mm. The three curves of Fig. 5 represent these three groups. I have watched the growth during the first summer, and know the first curve to represent the first summer's fish. The second curve in all probability represents the second year's fish, and the third curve, those three years old and over. The growth, thus, is most rapid during the first summer, the rate of growth decreasing each year after. The fish reaches practically its full size the third year, though the more gradual slope to the right of the last curve shows that it does not cease growing entirely.

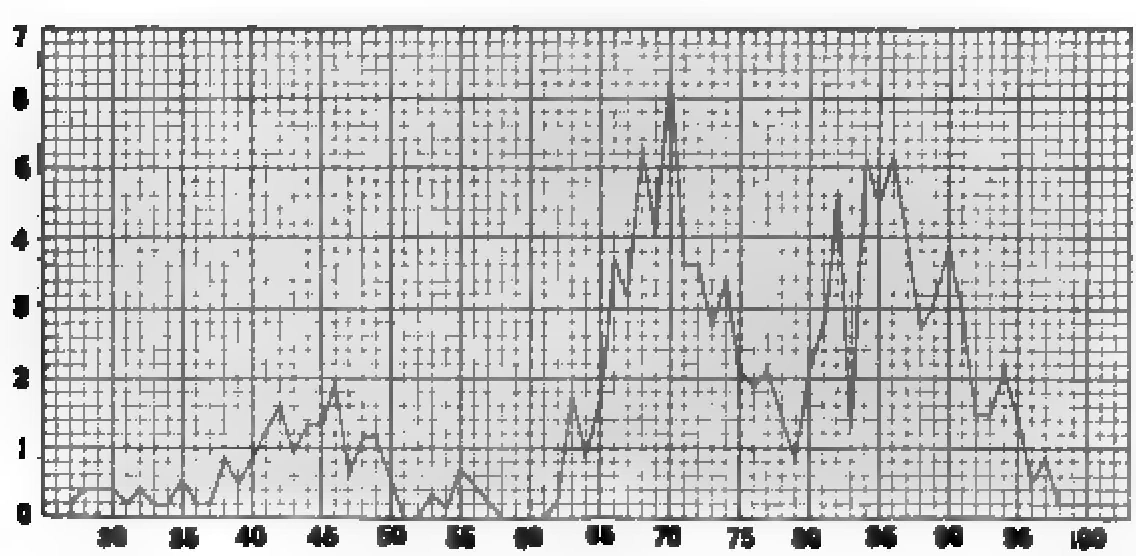

FIG. 5.

Having grouped them into three definite ages, a summary of the characters for each was made, and curves constructed. Figs. 6, 7, 8 and 9 represent the curves for these characters. In all the curves constructed for these ages, the continuous line is for the third year specimens, the broken line for the second year specimens and the dotted line for the first year specimens.

LATERAL LINE.—Below is the table of the average number of scales in the lateral line of the three ages.

	1st year.	*2d year.*	*3d year.*
Right side	87.84	90.80	88.39
Left side	88.00	89.80	88.78

From this it is seen that the first and third year specimens are most nearly alike. The second year specimens have about two scales more. By reference to the curves, Fig. 6, and Table VIII below, it will be seen that the great bulk of the specimens of all three ages have from 85 to 92 scales. The increased average in the second year is due to a larger per cent. having 93, 94, 95 and 96 scales than in the first and second years.

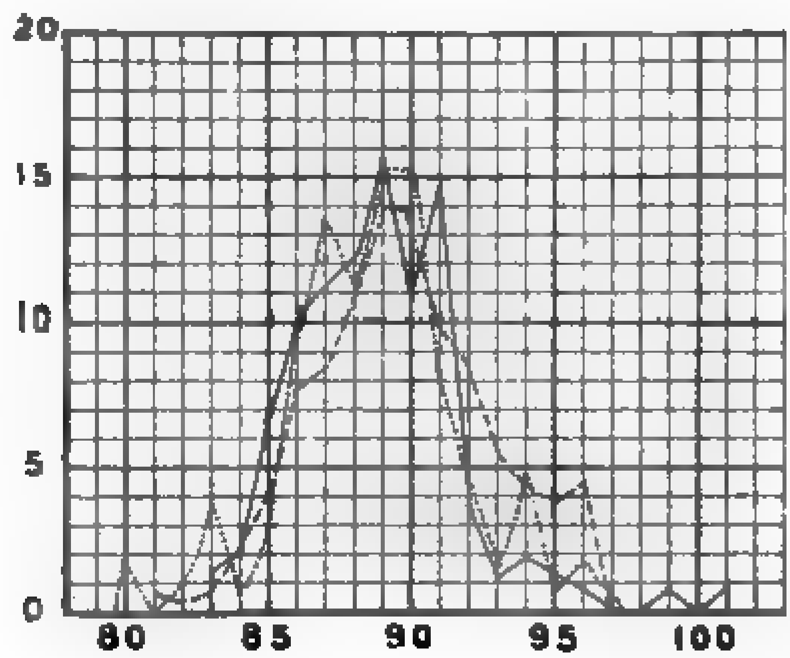

FIG. 6.

TABLE VIII

	Per Cent. of Specimens Having 80 Scales.	Per Cent. of Specimens Having 81 Scales.	Per Cent. of Specimens Having 82 Scales.	Per Cent. of Specimens Having 83 Scales.	Per Cent. of Specimens Having 84 Scales.	Per Cent. of Specimens Having 85 Scales.	Per Cent. of Specimens Having 86 Scales.	Per Cent. of Specimens Having 87 Scales.	Per Cent. of Specimens Having 88 Scales.	Per Cent. of Specimens Having 89 Scales.	Per Cent. of Specimens Having 90 Scales.	Per Cent. of Specimens Having 91 Scales.	Per Cent. of Specimens Having 92 Scales.	Per Cent. of Specimens Having 93 Scales.	Per Cent. of Specimens Having 94 Scales.	Per Cent. of Specimens Having 95 Scales.	Per Cent. of Specimens Having 96 Scales.	Per Cent. of Specimens Having 97 Scales.	Per Cent. of Specimens Having 98 Scales.	Per Cent. of Specimens Having 99 Scales.	Per Cent. of Specimens Having 100 Scales.	Per Cent. of Specimens Having 101 Scales.
First year specimens	1.90	.....	.96	3.84	.96	3.84	9.97	13.46	11.52	15.38	15.38	5.69	4.50	1.99	4.50	.96	1.92	.96	......	......	.	......
Second year specimens	.....	.85	.42	.85	2.14	4.29	7.72	8.58	10.73	13.73	13.73	9.87	8.58	5.57	4.29	3.86	4.29	4.29	.....	.....	......	..
Third year specimens	.....	..	.	1.22	2.04	7.35	10.24	11.47	12.28	15.57	11.06	14.34	3.67	2.47	2.86	3.68	.81	.40	..	.81		.40

Anal Fin.—Five out of 116 first year specimens have one anal spine; 6 out of 236 of the second year, and 3 out of 246 of the oldest specimens.

The average number of anal rays are 10.56 for the first year, 10.74 for the second year and 11.00 for the third year specimens.

The curves in Fig. 7 and Table IX, below, show that the anal fins of the first and second year specimens more nearly resemble each other. All three ages show a preference for 11.00 rays. The per cent. of specimens having this number are 51.69, 52.53 and 61.60 for the first, second and third year specimens respectively. The per cent. of specimens having 10 rays is reduced from 36.43 in the first year to 20.57 in the third year, and the per cent. of those having 12 rays is increased from 5.09 in the first year to 20.16 in the third year. There is a very evident increase in the number of spines with the age.

The extent of variation of the second and third year specimens is the same. The first year specimens, although only half as many, exceed the other ages two rays in the extent of variation.

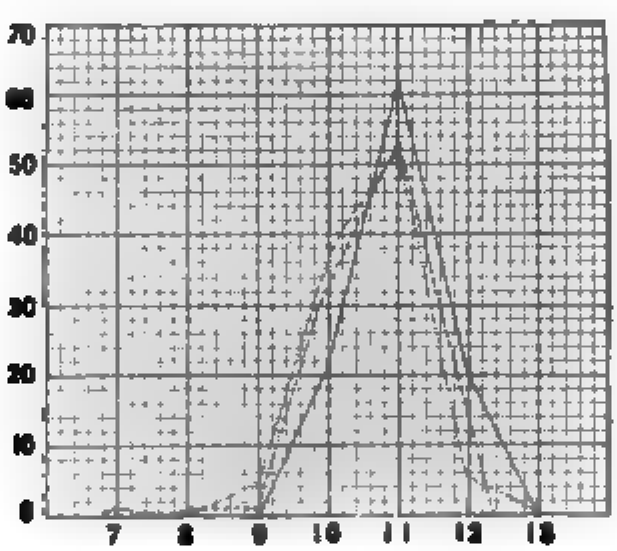

Fig. 7.

TABLE IX.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 7 anal rays ...	0.84	....	....
Per cent. of specimens having 8 anal rays	. .	0.42	.....
Per cent. of specimens having 9 anal rays	5.09	1.69	0.82
Per cent. of specimens having 10 anal rays ..	36.43	32.19	20.57
Per cent. of specimens having 11 anal rays	51.69	52.53	61.60
Per cent. of specimens having 12 anal says	5.09	13.12	20.16
Per cent. of specimens having 13 anal rays	0.84	. . .	0.82

Several important facts brought out by the preceding comparison are worth consideration.

1. No two of the ages here compared are alike in all the characters.

2. In the anal fin and soft dorsal there is a definite increase in the number of rays with the age.

3. Variation of this nature is not present in the other structures.

4. The extent of variation in the different ages is about the same.

DORSAL RAYS.—The average number of dorsal rays are 14.57, 14.76 and 14.98 for the first, second and third year specimens, respectively. There is a slight increase with age. The summaries for this structure are given below in Table XI, and the curves in Fig. 8. The prevailing number of rays is 15 for all three ages, the per cents. being 53.39, 52.53 and 55.69 for the first, second and third year specimens, respectively. The per cent. of specimens having 14 rays decreases from 40.72 in the first year to 22.35 in the third year specimens, while the per cent. of specimens having 16 rays increases from 3.38 in the first year specimens to 16.73 in the third year specimens. The extent of variation is from 12 to 16 in the first year, from 12 to 17 in the second year and from 13 to 18 in the third year specimens. As in the anal fin there is a tendency toward a greater number of rays as the fish grows older.

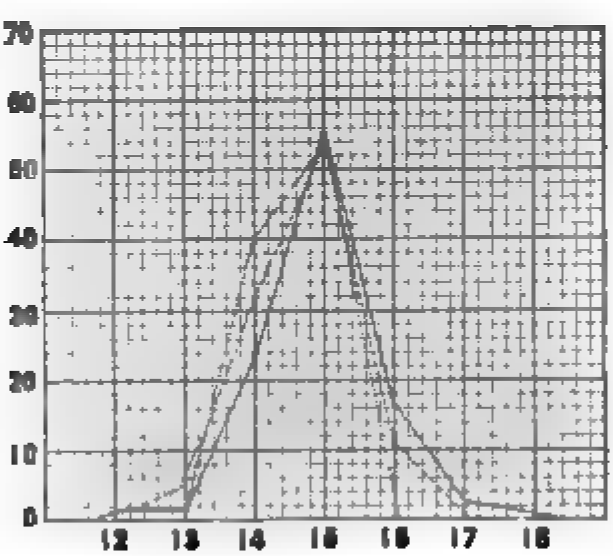

FIG. 8.

TABLE XI.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 12 dorsal rays	0.84	0.42	....
Per cent. of specimens having 13 dorsal rays	1.69	2.96	1.21
Per cent. of specimens having 14 dorsal rays	40.72	30.50	22.35
Per cent of specimens having 15 dorsal rays	53.39	52.53	53.69
Per cent. of specimens having 16 dorsal rays	3.38	11.48	16.73
Per cent. of specimens having 17 dorsal rays	....	0.84	3.25
Per cent. of specimens having 18 dorsal rays	....	....	0.40

DORSAL SPINES.—The averages for this structure are 14.69 for the first year, 14.39 for the second and 14.65 for the third year, the first and third years being almost identical, and the second year having a fewer number. Fig. 9 represents the curves for this structure. The curves of the first and third years are almost identical, both showing a preference for 15, with about 35 per cent. for 14. The second year shows as decided a preference for 14, about 35 per cent. for 15. This structure varies from 13 to 16 in the first year specimens, from 12 to 17 in the second year specimens and from 13 to 17 in the third year specimens. Table X contains the summaries for this structure.

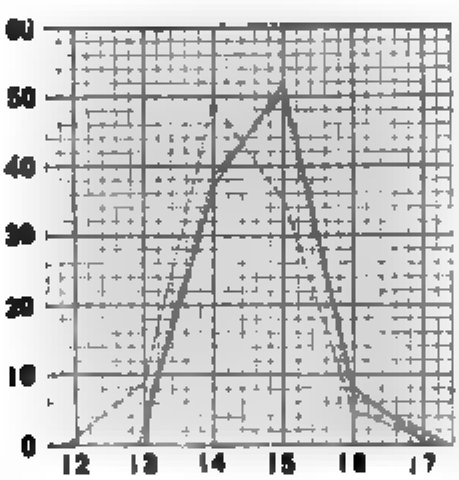

FIG. 9.

TABLE X.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 12 dorsal spines....	....	0.84	....
Per cent. of specimens having 13 dorsal spines....	1.69	8.47	3.65
Per cent. of specimens having 14 dorsal spines....	38.98	49.14	36.17
Per cent. of specimens having 15 dorsal spines....	50.00	35.16	51.62
Per cent. of specimens having 16 dorsal spines....	7.62	5.50	8.13
Per cent. of specimens having 17 dorsal spines....	....	0.42	0.40

The first and third year specimens resemble each other very closely in regard to the scales in the lateral line and the dorsal spines. In these characters the second year specimens show a decided difference. These have on an average two more scales in the lateral line, and have 14 as the prevailing number of dorsal spines instead of 15, the number in the first and third year specimens.

Several explanations might be suggested to account for a part or all of these differences.

The explanation suggesting itself most readily is that an additional spine and ray are added during the life of the individual. I have gone over all the specimens carefully with this point in view, but find no evidence either of the splitting of a ray or spine, or of the new growth of these, except at the anterior of the dorsal fins. Here may be found numerous instances of shorter spines and rays from two-thirds to one-fourth the normal length. But among so many specimens it is entirely probable that these spines and rays would be found in every possible stage of growth. But this is not the case. The spines and rays, although sometimes only one-fourth the full length, are always strong and suggest aborted rather than immature structures. Besides, if this were the case, we would expect to find the tendency toward a lower number of spines, and rays very decided in the first year specimens. While this condition is true in the dorsal and anal rays, it is decidedly not true in the dorsal spines, where the characters in the first years are almost identical with those of the third year.

Natural Selection.—The principle of natural selection, the influence of which upon this species I hoped in the onset of this work to find, can not be applied in explanation of the difference in the number of scales and dorsal spines without serious objections. If natural selection were the determining factor in producing these differences, we should expect all the variations graduated with the age. We would expect to have a narrower range of variation as the specimens

grow older. Neither of these conditions obtain. There are neither 18 dorsal rays nor 13 anal rays represented in the second year specimens; and in the first year specimens 17 dorsal rays are not represented. In the dorsal spines where the difference is most pronounced we have in the first year specimens the exact duplicate of that of the third year specimens, while the second year specimens are quite different. The scales in the lateral line present the same difficulty.

ANNUAL VARIATION.—The explanation that seems to meet all the conditions most satisfactory is that the species varies with the varying conditions of successive years.

The difference in the dorsal spines of the different ages accounts thus for the abnormality of the curve for the dorsal spines of all the Turkey Lake specimens, Fig. 4. The 600 specimens for which the curve is constructed is a composite lot of three age varieties.

This conclusion, however, should be held with some reservation. It will be noticed that nearly all the curves of Figs. 7, 8 and 9 are abnormal curves, which may possibly be due to the presence of local races in the lake. While this may possibly be the case, it is not at all probable, because, in the first place, the curve constructed for the dorsal spines of 100 specimens of three year olds, taken within a distance of 100 yards along the shores where the conditions were undoubtedly uniform, gave a curve identical with that for all the three year olds. In the second place, the second and third year specimens are found in about equal abundance together, and since these were promiscuously preserved it is altogether probable that from any given locality, an equal number of each age was taken.

The sex has been determined in all, and a summary shows that the sexes do not differ in the characters entering into the above considerations.

INDEX.

PROCEEDINGS

OF THE

Indiana Academy of Science.

1896

W. B. BURFORD, PRINTER,
INDIANAPOLIS.

PROCEEDINGS

OF THE

Indiana Academy of Science

1896.

INDIANAPOLIS, IND.
1897.

INDIANAPOLIS:
WM. B. BURFORD, PRINTER.
1897.

TABLE OF CONTENTS.

An Act to provide for the publication of the reports and papers of the Indiana Academy of Science.

[Approved March 11, 1895.]

Preamble.

Whereas, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State, and,

Whereas, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form, and,

Whereas, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement, therefore,

Publication of the reports of the Indiana Academy of Science.

Section 1. *Be it enacted by the General Assembly of the State of Indiana*, That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

Editing reports.

Sec. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery.

Number of printed reports.

Not less than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits, to be determined by the concurrent action of the editors and the Commissioners of Public

Printing and Stationery: *Provided*. That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

Proviso.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

Disposition of reports.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

Emergency.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

[Approved March 5, 1891.]

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That it shall be unlawful for any person to kill any wild bird other than a game bird, or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird.

Birds.

SEC. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act.

Game Birds.

Penalty.

SEC. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days.

Permits.

SEC. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act.

Permits to Science.

SEC. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege, and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed any bird or taken the nests or eggs of any bird for any other purpose than that named in this section, and shall further be subject for each offense to the penalties provided in this act.

Bond.

Bond forfeited.

Two years.

SEC. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of Prey.

SEC. 7. The English or European house sparrow (passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed.

SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency.

SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

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A. W. Butler, C. H. Eigenmann, W. P. Shannon.

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CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members

but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a president, vice-president, secretary, assistant secretary, and treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-presidents of the Academy, shall constitute an executive committee. The president shall, at each annual meeting appoint two members to be a committee which shall prepare the programmes and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the executive committee. There shall also be a summer meeting at such time and place as may be decided upon by the executive committee. Other meetings may be called at the discretion of the executive committee. The past presidents, together with the officers and executive committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The president shall deliver a public address on the evening of one of the days of the meeting at the expiration of his term of office.

3. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.

5. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

6. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

FELLOWS.

J. C. Arthur	*1893	Lafayette.
P. S. Baker	1893	Greencastle.
George W. Benton	1896	Indianapolis.
W. S. Blatchley	1893	Indianapolis.
J. C. Branner	1893	Palo Alto, Cal.
Wm. Lowe Bryan	1895	Bloomington.
A. W. Butler	1893	Brookville.
R. E. Call	1894	Lawrenceburg.
J. L. Campbell	1893	Crawfordsville.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
D. W. Dennis	1895	Richmond.
A. Wilmer Duff	1896	Lafayette.
C. H. Eigenmann	1893	Bloomington.
Katherine E. Golden	1895	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thos. Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
O. P. Hay	1893	Washington, D. C.
H. A. Huston	1893	Lafayette.
J. P. D. John	1893	Greencastle.
D. S. Jordan	1893	Stanford University, Cal.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
T. C. Mendenhall	1893	Worcester, Mass.

*Date of election.

Joseph Moore	*1896	Richmond.
D. M. Mottier	1893	Bloomington.
W. A. Noyes	1893	Terre Haute.
L. J. Rettger	1896	Terre Haute.
J. T. Scovell	1894	Terre Haute.
W. P. Shannon	1893	Greensburg.
Alex. Smith	1893	Chicago, Ill.
W. E. Stone	1893	Lafayette.
M. B. Thomas	1893	Crawfordsville.
L. M. Underwood	1893	New York City.
T. C. Van Nuys	1893	Bloomington.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Wooster, O.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

D. H. Campbell	Stanford University, Cal.
B. W. Evermann	Washington, D. C.
Charles H. Gilbert	Stanford University, Cal.
C. W. Green	Stanford University, Cal.
C. W. Hargitt	Syracuse, N. Y.
Edward Hughes	Stockton, Cal.
O. P. Jenkins	Stanford University, Cal.
J. S. Kingsley	Tufts College, Mass.
Alfred Springer	Cincinnati, O.
Robert B. Warder	Washington, D. C.

ACTIVE MEMBERS.

Frederick W. Andrews	Bloomington.
R. J. Aley	Bloomington.
George H. Ashley	Indianapolis.
Timothy H. Ball	Crown Point.
H. H. Ballard	Terre Haute.

*Date of election.

C. L. Barnes.................................Indianapolis.
Andrew J. Bigney.............................Moore's Hill.
J. A. Bergstrom..............................Bloomington.
A. W. Bitting................................Lafayette.
Alexander Black..............................Greencastle.
Edwin M. Blake...............................Lafayette.
Donaldson Bodine.............................Crawfordsville.
M. A. Brannon................................Ft. Wayne.
Charles C. Brown.............................Indianapolis.
H. L. Bruner.................................Irvington.
Severance Burrage............................Lafayette.
J. B. Burris.................................Cloverdale.
Noble C. Butler..............................Indianapolis.
Ada C. Campbell..............................South Bend.
J. T. Campbell...............................Rockville.
E. J. Chansler...............................Bicknell.
Fred. M. Chamberlain.........................Bloomington.
Walter W. Chipman............................Warsaw.
J. Fred. Clearwaters.........................Indianola, Ill.
George Clements..............................Crawfordsville.
H. J. Clements...............................Washington.
Charles Clickener............................Tangier.
U. O. Cox....................................Mankato, Minn.
M. E. Crowell................................Indianapolis.
Glenn Culbertson.............................Hanover.
Will Cumback.................................Greensburg.
Alida M. Cunningham..........................Kirkpatrick.
H. S. Cunningham.............................Indianapolis.
George L. Curtiss............................Columbus.
B. M. Davis..................................Irvington.
Martha Doan..................................Westfield.
J. P. Dolan..................................Syracuse.
Chas. R. Dryer...............................Terre Haute.
Joseph Eastman...............................Indianapolis.
E. G. Eberhardt..............................Indianapolis.
M. N. Elrod..................................Hartsville.
F. L. Emory..................................Morgantown, W. Va.
Percy Norton Evans...........................Lafayette.

Samuel G. Evans	Evansville.
E. M. Fisher	Lake Forest, Ill.
J. J. Flather	Lafayette.
A. L. Foley	Bloomington.
Robert G. Gillum	Terre Haute.
J. R. Francis	Indianapolis.
Austin Funk	Bloomington.
J. B. Garner	Crawfordsville.
U. F. Glick	Newbern.
Michael J. Golden	Lafayette.
W. E. Goldsborough	Lafayette.
S. S. Gorby	Franklin.
Vernon Gould	Rochester.
J. C. Gregg	Brazil.
E. H. Heacock	Topeka, Kas.
Chas. A. Helvie	Chicago.
Wm. Perry Hay	Washington, D. C.
Franklin W. Hays	Indianapolis.
Flora Herr	Bloomington.
Robert Hessler	Logansport.
T. E. Hibben	Indianapolis.
J. W. Hubbard	Bloomington.
Lucius M. Hubbard	South Bend.
Thomas M. Iden	Irvington.
Alex. Jameson	Indianapolis.
A. E. Jessup	Carmel.
Sylvester Johnson	Irvington.
W. B. Johnson	Franklin.
Chancey Juday	Bloomington.
O. L. Kelso	Terre Haute.
Arthur Kendrick	Terre Haute.
E. M. Kindle	Bloomington.
J. G. Kingsbury	Irvington.
Ph. Kirsch	ColumbiaCity.
Charles T. Knipp	Bloomington.
Thomas Large	Rensselaer.
Daniel Layman	Indianapolis.
V. H. Lockwood	Indianapolis.

Herbert W. McBride.............................Indianapolis.
Robert Wesley McBride..........................Indianapolis.
Kate McCarthy..................................Wabash.
Rousseau McClellan.............................Indianapolis.
D. T. McDougal.................................Minneapolis, Minn.
J. W. Marsee...................................Indianapolis.
G. W. Martin...................................Indianapolis.
Franklin S. Miller.............................Brookville.
W. J. Moenkhaus................................Bloomington.
G. T. Moore....................................Crawfordsville.
J. P. Naylor...................................Greencastle.
Charles E. Newlin..............................Irvington.
John F. Newsom.................................Elizabethtown.
E. W. Olive....................................Frankfort.
J. H. Oliver...................................Indianapolis.
D. A. Owen.....................................Franklin.
George J. Peirce...............................Bloomington.
W. H. Peirce...................................Indianapolis.
Elwood Pleas...................................Dunreith.
A. H. Purdue...................................Chicago, Ill.
Ryland Ratliff.................................Fairmount.
H. G. Reddick..................................Bloomington.
Bessie C. Ridgley..............................South Bend.
D. C. Ridgley..................................Delphi.
Curtis A. Rinson...............................Bloomington.
George L. Roberts..............................Greensburg.
Adolph Rodgers.................................New Castle.
John F. Schnaible..............................Lafayette.
C. E. Schafer..................................Huntington.
E. A. Schultze.................................Noblesville.
Claude Siebenthal..............................Bloomington.
G. W. Sloan....................................Indianapolis.
J. B. Slonaker.................................Bloomington.
Richard A. Smart...............................Lafayette.
Harold B. Smith................................Worcester, Mass.
Theo. W. Smith.................................Indianapolis.
Lillian Snyder.................................West Lafayette.
F. P. Stauffer.................................Logansport.

M. C. Stevens	Lafayette.
H. M. Stoops	Brookville.
Joseph Swain	Bloomington.
William Stewart	Lafayette.
George A. Talbert	Laporte.
Frank B. Taylor	Fort Wayne.
S. N. Taylor	West Lafayette.
Erastus Test	Lafayette.
F. C. Test	Washington, D. C.
J. F. Thompson	Richmond.
William M. Thrasher	Irvington.
A. L. Treadwell	Oxford, Ohio.
W. P. Turner	West Lafayette.
A. B. Ulrey	North Manchester.
W. B. Van Gorder	Knightstown.
H. S. Voorhees	Brookville.
J. H. Voris	Bloomington.
Ernest Walker	New Albany.
F. A. Walker	Anderson.
W. P. Wallheiser	Bedford.
W. O. Wallace	Wabash.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
J. R. Wiest	Richmond.
W. L. Wood	Covington.
William Watson Woollen	Indianapolis.
A. J. Woolman	Duluth, Minn.
P. A. Yoder	Bloomington.
A. C. Yoder	Bloomington.
O. B. Zell	Clinton.

Fellows	41
Non-resident members	10
Active members	149
Total	200

LIST OF FOREIGN CORRESPONDENTS.

AFRICA.

Dr. J. Medley Wood, Natal Botanical Gardens, Berea Durban, South Africa.
South African Philosophical Society, Cape Town, South Africa.

ASIA.

China Branch Royal Asiatic Society, Shanghai, China.
Asiatic Society of Bengal, Calcutta, India.
Geological Survey of India, Calcutta, India.
Indian Museum of India, Calcutta, India.
India Survey Department of India, Calcutta, India.

Deutsche Gesellschaft für Natur und Volkerkunde Ostasiens, Tokio, Japan.
Imperial University, Tokio, Japan.

Koninklijke Naturkundige Vereeniging in Nederlandsch-Indie, Batavia, Java.

Hon. D. D. Baldwin, Honolulu, Hawaiian Islands.

EUROPE.

V. R. Tschusizu Schmidhoffen, Villa Tannenhof, Halle in Salzburg, Austria.
Herman von Vilas, Innsbruck, Austria.
Ethnologische Mittheilungen aus Ungarn, Budapest, Austro-Hungary.
Mathematische und Naturwissenschaftliche Berichte aus Ungarn, Budapest, Austro-Hungary.
K. K. Geologischen Reichssanstalt, Vienna (Wien), Austro-Hungary.
K. U. Naturwissenschaftliche Gesellschaft, Budapest, Austro-Hungary.
Naturwissenschaftlich-Medizinischer Verein in Innsbruck (Tyrol), Austro-Hungary.

Editors "Termeszetrajzi Fuzetk," Hungarian National Museum, Budapest, Austro-Hungary.
Dr. Eugen Dadai, Adj. am Nat. Mus., Budapest, Austro-Hungary.
Dr. Julius von Madarasz, Budapest, Austro-Hungary.
K. K. Naturhistorisches Hofmuseum, Vienna (Wien), Austro-Hungary.
Ornithological Society of Vienna (Wien), Austro-Hungary.
Zoölogische-Botanische Gesellschaft in Wien, Wien, Austro-Hungary.
Dr. J. von Csato, Nagy Enyed, Austro-Hungary.

Malacological Society of Belgium, Brussells, Belgium.
Royal Academy of Science, Letters and Fine Arts, Brussells, Belgium.
Royal Linnean Society, Brussells, Belgium.
Societé Belge de Geologie, de Palaeontologie et Hydrologie, Brussells, Belgium.
Societé Royale de Botanique, Brussells, Belgium.
Societé Geologique de Belgique, Liège, Belgium.

Prof. Christian Frederick Lutken, Copenhagen, Denmark.

Bristol Naturalists' Society, Bristol, England.
Geological Society of London, London, England.
Linnean Society of London, London, England.
Liverpool Geological Society, Liverpool, England.
Manchester Literary and Philosophical Society, Manchester, England.
"Nature," London, England.
Royal Botanical Society, London, England.
Royal Geological Society of Cornwall, Penzance, England.
Royal Microscopical Society, London, England.
Zoölogical Society, London, England.
Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.
Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.
F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.
Hon. E. L. Layard, Budleigh Salterton, Devonshire, England.
Mr. Osbert Salvin, Hawksfold, Fernshurst, Haslemere, England.
Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England,
Phillip L. Sclater, 3 Hanover Sq., London W., England.
Dr. Richard Bowlder Sharpe, British Mus. (Nat. Hist.), London, England.
Prof. Alfred Russell Wallace, Corfe View, Parkstone, Dorset, England.

Botanical Society of France, Paris, France.
Ministèrè de l'Agriculture, Paris, France.
Societé Entomologique de France, Paris, France.
L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux, France.
Soc. de Horticulture et de Botan. de Marseille, Marseille, France.
Societé Linneenne de Bordeaux, Bordeaux, France.
La Soc. Linneenne de Normandie, Caen, France.
Soc. des Naturelles, etc., Nantes, France.
Zoölogical Society of France, Paris, France.
Baron Louis d'Hamonville, Meurthe et Moselle, France.
Prof. Alphonse Milne-Edwards, Rue Cuvier, 57, Paris, France.

Botanischer Verein der Provinz Brandenburg, Berlin, Germany.
Deutche Geologische Gesellschaft, Berlin, Germany.
Entomologischer Verein in Berlin, Berlin, Germany.
Journal für Ornithologie, Berlin, Germany.
Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.
Augsburger Naturhistorischer Verein, Augsburg, Germany.
Count Hans von Berlspsen, Münden, Germany.
Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.
Bremer Naturwissenschaftlicher Verein, Bremen, Germany.
Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle, Saxony, Germany.
Königlich-Sachsische Gesellschaft der Wissenschaften, Mathematische-Physische Classe, Leipzig, Saxony, Germany.
Naturhistorische Gesellschaft zu Hanover, Hanover, Prussia, Germany.
Naturwissenschaftlicher Verein in Hamburg, Hamburg, Germany.
Verein für Erdkunde, Leipzig, Germany.
Verein für Naturkunde, Weisbaden, Prussia.

Belfast Natural History and Philosophical Society, Belfast, Ireland.
Royal Dublin Society, Dublin.

Societa Entomologica Italiana, Florence, Italy.
Prof. H. H. Giglioli, Museum Vertebrate Zoölogy, Florence, Italy.
Dr. Alberto Perngia, Museo Civico di Storia Naturale, Genoa, Italy.
Societa Italiana de Scienze Naturali, Milan, Italy.
Societa Africana d' Italia, Naples, Italy.
Dell 'Academia Pontifico de Nuovi Lincei, Rome, Italy.
Minister of Agriculture, Industry and Commerce, Rome, Italy.
R. Comitato Geologico d' Italia, Rome, Italy.
Rassegna della Scienze Geologiche in Italia, Rome, Italy.
Prof. Count. Tomasso Salvadori, Zoölog. Museum, Turin, Italy.

Royal Norwegian Society of Sciences. Throndhjem, Norway.
Dr. Robert Collett, Kongl. Frederiks Univ., Christiana, Norway.

Academia Real des Sciencias de Lisboa, Lisboa (Lisbon), Portugal.

Comité Geologique de Russie, St. Petersburg, Russia.
Imperial Academy of Sciences, St. Petersburg, Russia.
Imperial Society of Naturalists, Moscow, Russia.

The Botanical Society of Edinburgh, Edinburgh, Scotland.
John J. Dalgleish, Brankston Grange, Bogside Sta., Sterling, Scotland.
Edinburgh Geological Society, Edinburgh, Scotland.
Geological Society of Glasgow, Scotland.
John A. Harvie-Brown, Duniplace House, Larbert, Stirlingshire, Scotland.
Natural History Society, Glasgow, Scotland.
Philosophical Society of Glasgow, Glasgow, Scotland.
Royal Society of Edinburgh, Edinburgh, Scotland.
Royal Physical Society, Edinburgh, Scotland.

Barcelona Academia de Ciencias y Artes, Barcelona, Spain.
Royal Academy of Sciences, Madrid, Spain.

Institut Royal Geologique de Suède, Stockholm, Sweden.
Société Entomologique à Stockholm, Stockholm, Sweden.
Royal Swedish Academy of Science, Stockholm, Sweden.

Naturforschende Gesellschaft, Basel, Switzerland.

Naturforschende Gesellschaft in Berne, Berne, Switzerland.

La Societé Botanique Suisse, Geneva, Switzerland.

Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.

Societé de Physique et d' Historie Naturelle de Geneva, Geneva, Switzerland.

Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.

Naturforschende Gesellschaft, Zürich, Switzerland.

Schweizerische Botanische Gesellschaft, Zürich, Switzerland.

Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.

Royal Society of New South Wales, Sidney, New South Wales.

Prof. Liveridge, F. R. S., Sidney, New South Wales.

Hon. Minister of Mines, Sidney, New South Wales.

Mr. E. P. Ramsey, Sidney, New South Wales.

Royal Society of Queensland, Brisbane, Queensland.

Royal Society of South Australia, Adelaide, South Australia.

Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.

Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.

Canadian Record of Science, Montreal, Canada.

McGill University, Montreal, Canada.

Natural Society, Montreal, Canada.

Natural History Society, St. John, New Brunswick.

Nova Scotian Institute of Science, Halifax, N. S.

Manitoba Historical and Scientific Society, Winnipeg, Manitoba.

Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontario.

The Royal Society of Canada, Ottawa, Ontario.

Natural History Society, Toronto,Canada.

Hamilton Association Library, Hamilton, Ontario.

Minister of Militia and Defense, Ottawa, Ontario.

Canadian Entomologist, Ottawa, Ontario.

Department of Marine and Fisheries, Ottawa, Ontario.

Ontario Agricultural College, Guelph, Ont.
Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ont.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ont.
La Naturaliste Canadian, Chicontini, Quebec.
La Naturale Za, City of Mexico.
Mexican Society of Natural History, City of Mexico.
Museo Nacionale, City of Mexico.
Sociedad Cientifica Antonio Alzate, City of Mexico.
Sociedad Mexicana de Geographia y Estadistica de la Republica Mexicana, City of Mexico.

WEST INDIES.

Victoria Institute, Trinidad, British West Indies.
Museo Nacional, San Jose, Costa Rica, Central America.
Dr. Anastasia Alfaro, Secy. National Museum, San Jose, Costa Rica.
Rafael Arango, Havana, Cuba.
Jamaica Institute, Kingston, Jamaica, West Indies.

SOUTH AMERICA.

Argentina Historia Natural Florentine Amegline, Buenos Ayres, Argentine Republic.
Musée de la Plata, Argentine Republic.
Nacional Academia des Ciencias, Cordoba, Argentine Republic.
Sociedad Cientifica Argentina, Buenos Ayres.

Museo Nacional, Rio de Janeiro, Brazil.
Sociedad de Geographia, Rio de Janeiro, Brazil.
Dr. Herman von Jhering, Dir. Zoöl. Sec. Con. Geog. e Geol. de Sao Paulo, Rio Grande do Sul, Brazil.

Deutscher Wissenschaftlicher Verein in Santiago, Santiago, Chili.
Societé Scientifique du Chili, Santiago, Chili.
Sociedad Guatemalteca de Ciencias, Guatemala, Guatemala.

. . . PROGRAM . . .

OF THE

TWELFTH ANNUAL MEETING

OF THE

Indiana Academy of Science,

STATE HOUSE, INDIANAPOLIS,

December 30 and 31, 1896.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

STANLEY COULTER	President	AMOS W. BUTLER,	T. C. MENDENHALL,
THOMAS GRAY	Vice-President	W. A. NOYES,	JOHN C. BRANNER,
JOHN S. WRIGHT	Secretary	J. C. ARTHUR,	J. P. D. JOHN,
A. J. BIGNEY	Assistant Secretary	J. L. CAMPBELL,	JOHN M. COULTER,
W. P. SHANNON	Treasurer	O. P. HAY,	DAVID S. JORDAN.

The sessions of the Academy will be held in the State House in the rooms of the State Board of Agriculture.

Headquarters will be at the Denison Hotel. A rate of $2.50 per day will be made to all persons who make it known at the time of registering that they are members of the Academy.

Reduced railroad rates for the members can not be obtained under the present rulings of the Traffic Association. Many of the colleges can secure special rates on the various roads. Those who can not do this could join the State Teachers' Association and thus secure the one and one-third round-trip fare accorded to them.

C. A. WALDO,
A. J. BIGNEY,
Committee.

GENERAL PROGRAM.

Tuesday, December 29.

Meeting of the Executive Committee at the Denison Hotel .... 8 p. m

Wednesday, December 30.

General Session .... 9 a. m. to 12 m.
Sectional Meeting .... 2 p. m. to 5 p. m.
Address by President Stanley Coulter .... 7 p. m.

Thursday, December 31.

General Session, followed by Sectional Meetings .... 9 a. m. to 12 m.
General Session .... 2 p. m. to 4 p. m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

PROFESSOR STANLEY COULTER,

At 7 o'clock Wednesday evening.

Subject: "Science and the State."

The address has been placed at this early hour in order that other engagements for the usual hours of evening entertainment may not keep the members of the Academy and their friends from being present.

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*pari passu*" in sectional meetings. In order that the labor of presentation may be relieved, papers presented by the same authors have been separated unless such separation would impair the value of the papers. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time was sent with the papers, they have been uniformly assigned ten minutes. Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By order of the Academy, no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL SUBJECTS.

1. Evolution of map of Mammoth Cave, Ky. (Exhibition of all maps, ever made.) 10 m.......................... R. Ellsworth Call.
2. Fauna of Mammoth Cave with exhibition of specimens, 20 m.......................... R. Ellsworth Call.
3. Notes on Indiana caves and their fauna, 20 m.......... W. S. Blatchley.
4. A possible relation of the Academy of Science to the Teachers of Biology in our High Schools, 12 m.......................... L. J. Rettger.
5. The occurrence of Uroglena in the LaFayette City water, 10 m.......................... Severance Burrage.
6. Relation of the engineering research laboratory to the public, 12 m.......................... W. F. M. Goss.
7. Louisville filtration experiments, 10 m.......................... Geo. W. Benton.
8. A "Tornado" in Rush County, Indiana, August 1, 1896, 10 m.......................... W. P. Shannon.

GEOLOGICAL SUBJECTS.

9. Crushing strength of Bedford Oölitic limestone in cubes and prisms, 10 m........W. K. Hatt.
10. Some mounds of Vanderburg County, Indiana, 10 m........A. H. Purdue.
11. The Lake Michigan and Mississippi Valley water shed, 5 m....T. H. Ball.
*12. Some Indiana eskers, 15 m........Chas. R. Dreyer.
13. Some facts concerning sand ridges and beds, water courses, wells and Springs in Lake County, 10 m........T. H. Ball.
14. Report of a moraine of Niagara limestone, near Ricmond, 10 m. Jos. Moore.

MATHEMATICAL SUBJECTS.

15. A new formula for determining the friction of shafting......J. J. Flather.
16. Orthogonal surfaces, 20 m........A. S. Hathaway.
17. The Calendar Group, 10 m........C. A. Waldo.
18. Study of euthymorphic function of the first order, 10 m......E. M. Blake.
19. New mechanical computer, 20 m........Fred Morley.

PHYSICAL SUBJECTS.

20. A new apparatus for photographic surveying, 20 m..........Fred Morley.
21. Experiments on the surface tension of water above 100° C., 8 m. Chas. T. Knipp.
22. Crushing strength of wrought iron cylinders, 10 m. W. K. Hatt and L. Fletemeyer.
23. Test of a 60,000 lb. car axle, 5 m........W. F. M. Goss.
24. Subdivision of power, 10 m........J. J. Flather.
25. Electromagnets........W. E. Goldsborough.
26. An efficiency surface for Pelton motor, 5 m........W. K. Hatt.
27. On seiches, 15 m........A. W. Duff.
28. Some experiments on the phenomenon of the elevation of the elastic limit, 10 m........W. K. Hatt.
29. Empirical formula for viscosity as a function of temperature, 10 m........A. W. Duff.
30. Cadmium cells as compared with the standard Clark cells, 10 m, S. N. Taylor.

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*Author absent; paper not presented.

CHEMICAL SUBJECTS.

31. Soil solvents, 10 m.....................H. A. Huston and J. M. Barrett.

*32. The occurrence of Raffinose in American beet sugar, 10 m.
W. E. Stone and W. H. Baird.

33. Basic slag, 10 m........................ H. A. Huston and W. J. Jones.

*34. The action of enzymes upon starches of different origin, 10 m..W. E. Stone.

35. The character of the volatile matter lost by bituminous coal at 100° C. 15 m....................................W. E. Burk.

†36. Notes on the relation of Sodium Silicate to alcoholic fermentation, 5 m..Geo. W. Benton.

37. Notes on Diphenylselenon and Selenthren, 2 m..............Robert Lyon.

38. Notes on L- and B- Lupanin, 10 m ....Sherman Davis.

39. The physiological action of compounds containing bivalent carbon, 20 m... J. U. Nef.

40. Calculation of heating effect of coals by proximate analysis..W. E. Noyes.

BOTANICAL SUBJECTS.

41. Notes on the flora of Lakes Cicott and Maxinkuckee, 5 m..Robert Hessler.

42. Notes on some Phanerogams, new or rare to the State, 10 m..W. S. Blatchley.

43. Periodicity of root pressure, 15 m ....M. B. Thomas.

44. Notes on the flora of the lake region of northeastern Indiana, 20 m...W. W. Chipman.

45. Contribution to the flora of Indiana IV, 15 m.............Stanley Coulter.

46. Additions to the published lists of Indiana cryptogams..L. M. Underwood.

47. Changes in the pith cell preliminary to the development of cavities in the stems of some grasses, 15 m.......................G. J. Peirce.

48. Bacteria found in the air of stables, 15 m..................A. W. Bitting.

49. Have the common yeasts pathogenic properties? An experimental study, 15 m ....Katherine E. Golden.

50. Exceptional growth of a wild rose, 5 m ....Stanley Coulter.

51. A revision of the species of the genus Plantago occurring in the United States, 15 m..........................Alida M. Cunningham.

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*Author absent; paper not presented.

†Paper not presented.

52. A microscopic examination of certain drinking waters, 15 m.
G. J. Peirce, F. M. Andrews and A. C. Life.
53. The effect of drought upon certain plants--an experimental study, 15 m .... Clara A. Cunningham.
54. Additions to the Cryptogamic flora of Indiana, 10 m......... J. C. Arthur.
55. The Uredineæ of Tippecanoe County, Indiana, 10 m....... Lillian Snyder.
56. Traumatropic curvatures of tendrils, 5 m................ D. T. McDougal.
57. Mechanism of curvatures of roots, 5 m.................. D. T. McDougal
58. The occurrence of the Russian Thistle (Salsola Kali Tragus) in Wabash County, 5 m.................................... A. B. Ulrey.

ZOÖLOGICAL SUBJECTS.

59. Some additions to our knowledge of the anatomy and embryology of the Holostomidæ, 10 m.................. .... L. J. Rettger.
60. Abnormal incisor growths in rodents, 5 m.................. C. E. Newlin.
61. The Bobolink (Dolichony and oryzivorous) in Indiana, 15 m..A. W. Butler.
62. The birds, our friends, 12 m............................. E. J. Chandler.
63. Some additions to the Indiana bird list, with other notes, 15 m..A. W. Butler.
64. Some interesting bones, 5 m.............................. M. B. Thomas.
65. The hydrographic basins of Indiana and their Molluscan fauna, 10 m... R. Ellsworth Call.
66. The American Indian—his religion, 15 m................ Geo. L. Curtiss.
67. Notes on the origin of the epiphysis cerebri of Amia, 5 m..... B. M. Davis.
68. Summary of the literature on the epiphysis cerebri, 5 m...... B. M. Davis.
69. The snowbird at night, 5 m............................ W. P. Shannon.
70. On the occurrence of several families of aquatic animalculæ in new stations, 3 m.. E. Pleas.
71. Notes on the biological survey of Milan Pond, 10 m.......... A. J. Bigney.
72. Involuntary suicide of a crow, 3 m .... Stanley Coulter.
73. A brief history of the Randolph Mastodon, 10 m.............. Jos. Moore.
74. The increasing abundance of the opossum (Didelphus virginiana Shaw) in northern Indiana, 5 m......................... A. B. Ulrey.

TURKEY LAKE AS A UNIT OF ENVIRONMENT AND THE VARIATION OF ITS INHABITANTS.

TWELFTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The twelfth annual meeting of the Indiana Academy of Science was held in Indianapolis Wednesday and Thursday, December 30 and 31, 1896, preceded by a session of the executive committee of the Academy, 8 P. M., Tuesday, December 29th.

At 9 A. M., December 30th, President Stanley Coulter called the Academy to order in general session, at which committees were appointed and much other routine and miscellaneous business transacted. After the disposition of these affairs the reading and discussion of papers of the printed program, under the title of "General Subjects," occupied the time until adjournment at 12 M.

The Academy met at 2 P. M., in two sections—biological and physico-chemical—for the reading and discussion of papers. President Stanley Coulter presided over the biological section, and Vice-President Thomas Gray acted as chairman of the physico-chemical section. After the adjournment of the section meetings at 5 P. M. the Academy again met in general session at 7 P. M. Following the disposition of committee reports and the transaction of other business was the address of the retiring President, Dr. Stanley Coulter, subject: "Science and the State."

The evening session of the Academy was followed by a meeting of the executive committee.

Thursday, December 31st, 9:15 A. M., the Academy met in general session for the transaction of business, after which it divided into sections for the consideration of papers. President Coulter presided over the biological section, while Prof. W. B. Johnson acted as chairman of the physico-chemical section.

Adjournment of each section about 12 M.

THE FIELD MEETING OF 1896.

The Field Meeting of 1896 was held Thursday and Friday, June 4th and 5th, at Oxford, Ohio. This, the first session of the Indiana Academy held out of the State, was in connection with the field meeting of the Ohio Academy of Science.

Thursday, June 4th, was largely spent in the field. At 8 P. M. the two academies met at the Western Female Seminary, where President Stanley Coulter, of the Indiana Academy, delivered an address, subject: "The Influence of Biology upon the World."

The executive committee of the Indiana Academy met in business session at 7:30 A. M., Friday, June 5th, President Stanley Coulter in the chair. Both academies occupied much of the day with various excursions, after which they visited Oxford College. In the evening, at Miami University, Dr. R. Ellsworth Call delivered an illustrated lecture on Mammoth Cave. Adjournment.

The joint meeting of the Indiana and Ohio Academies of Science was an occasion of more than usual interest. The academies were laid under heavy obligations to Oxford citizens, who individually and through the various educational institutions spared no efforts to make the event enjoyable and profitable.

Science and the State. By Stanley Coulter.

Presidential Address, Indiana Academy of Science, December 30, 1896.

I recognize the fact that innovation is dangerous, especially when it involves an attempt to give definite form to thoughts, which in varying degrees of distinctness are common property. Yet, despite this danger, I feel constrained to depart somewhat from the usual line of presidential addresses, and, instead of presenting a paper based upon research work or upon achievement in any one department of science, to treat in somewhat broad lines the *relation of science to the State.*

I trust that I may be able to show that the relation is one which involves duty—personal and associate—offers opportunities and opens splendid possibilities. I am led to this course, partially, at least, in the hope that the existing relation between the Academy and the State may be shown to be not only a natural one, but one of extreme mutual advantage.

Science, as every other branch of knowledge, may be considered from two points of view, and the view-point has much to do with the aspect she wears. To the student filled with the scientific spirit the truths she offers are not only inspiration, but sufficient reward. In no other guise can she wear so fair a form.

To the mass of humanity science is beautiful only as she is useful, worthy as she is helpful.

I am one who stands for the exceeding strength and beauty of pure science, who believes it not only strong and beautiful, but fundamental, the *sine qua non* of the useful, and yet as one who is forced to feel that perhaps the world has gained more from "Dobbin" than from "Pegasus." It is possible, too, that you and I may have wrong conceptions of just what is meant by the term pure science.

The old monastic idea of the scholar and of scholarship still persists. It finds, perhaps, its highest utterance in Prof. Woodrow Wilson's address at the Princeton Sesquicentennial celebration, where he says that for him the university is—

"A place removed—calm science seated there, recluse, ascetic, like a nun, not knowing that the world passes, not caring if the truth but come in answer to her prayer; and literature, walking within open doors in quiet chambers with men of olden time, storied walls about her and calm voices infinitely sweet; here 'magic casements opening on the foam of perilous seas in fairy lands forlorn,' to which you may withdraw and use your youth for pleasure."

It finds its every-day utterance in the sneer of the party organ at the scholar who raises his voice in affairs political, and in the expressed belief of the masses that scholars are impractical and theoretical. I care not from what source it may

come or with what authority it may be voiced, such a conception of the scholar and of scholarship is utterly at variance with existing facts. I believe this to be true in all realms of thought. I know it to be true in the realm of science. The development of this wonderfully brilliant and complex composite, which we call modern civilization, has been due to the interplay of many factors, and not the least of these in these latter days has been science. During the last decade, indeed, science seems to have been the dominating factor in human affairs. It is not necessary in this presence to recount the manifold applications of the truths of science to the affairs of every-day life. Science has stretched out her hand and touched transportation and manufactures and agriculture, and with the touch has given a fuller and more abundant life. She has gone into the home and municipality, and by her presence has minimized the dangers of disease. She has entered the office of the physician and surgeon and given a power that even in this day of wonders seems marvelous. Her influence is felt in school, in philosophy, in church and is surely, though perhaps somewhat slowly, bringing these great forces into a closer touch, a more complete harmony with the life that is. Each day in the clear light of the truth, given as the rewards of her devotees, clouds of superstition and ignorance lose form and vanish into nothingness.

To one in touch with science and her achievements she seems no "*recluse*," no "*ascetic*," very little "*like a nun, not knowing that the world passes*," but rather as a virile force pervading the world in all of its affairs, a force as potent as pervading.

And yet in spite of this broad view there exists in our own cases even a somewhat natural tendency to withdraw from the affairs of common weal into the shell of specialty. We justify this withdrawal by some plea of "truth for truth's sake" or talk learnedly about "pure science" as if it were a thing apart from human affairs. The fact plainly stated is, that science has not done as much for the State as it should. I do not refer especially to Indiana and the scientist of Indiana, but to science and the State in the broadest possible application of the terms.

The monastic idea has prevailed too largely among scientists, and science has not done its full duty by the State. Do not imagine for a moment that I am tacitly admitting the converse of the statement that the State is doing for science more than it merits. The failure in duty is mutual. Science has largely failed to seize her opportunities; the State has almost utterly failed to utilize one of her most potent forces. Many things have conspired to bring about this state of affairs, one no doubt, that somewhat vague something known as "practical politics." Another, equally vague ideas on the part of scientists as to what science can do for the State.

I may premise by saying that the State as a rule can not deal in intellectual futures. It can not or should not make appropriations for investigations to run through long series of years, the ultimate outcome of which is merely the solution of some scientific problem. To the scientist such problems are of the profoundest interest, their solution seems to him of almost paramount importance, and yet a moment's reflection will serve to show that the State can not properly provide for such work. The State has to deal, not with the general problems of science, save as they are applicable to immediate needs, but with the welfare of her citizens. Welfare being a term under present conditions, which seems to be largely material in its interpretation, incidentally intellectual, remotely moral.

If I am right in this view, it follows that the first duty of science to the State is the *development and protection of her material resources.* This may appear, at first, a lowering of the high ideals many of us hold, and yet as we increase the resources of our commonwealth, we manifestly increase the possibility of the attainment of our high ideals. "Untoward circumstances" has blighted many a scientific aspiration. An increase in material prosperity is the shortest cut to an increase in the intellectual activity and development of the State. As intellectual activity is increased, the constituency appreciating the value of scientific work increases, opportunities broaden and achievement is possible. I am inclined to think that the duty to increase and conserve the material resources of the State may be found to be the all inclusive duty of science, since if thoroughly done, all other desired conditions will naturally follow. To become concrete. For a long series of years the State has maintained a geological survey. I believe that in spite of the numerous criticisms that can justly be made upon the published reports, no wiser or more productive expenditure of public moneys has been made. If all conditions are considered, limitations of opportunity, uncertain and meagre appropriations, illogical selection of the official chief by popular vote, control over the extent and character of the reports by committees and the sundry other stumbling blocks in the way of the highest efficiency, the results are surprisingly good. As individuals and as an association, I believe we have failed in our duty to the State as regards these publications. It goes without saying that the work of the State Geologist would have been made infinitely simpler, that his reports would have had a higher value if he had received during the past ten years the hearty individual and associate co-operation of this Academy. We have, in a degree, lost an opportunity to make science and the scientist a factor in the material advance of the State.

In my opinion the first duty of the members of this Academy is a complete study of the material resources of the county in which they reside. Not, for example, a list of flowers, unless it is indicative of soils, of drainage, of forest wealth, of forage resources, of the numerous facts of which the list stands as index. Not a mere list of birds, or fish, or insects, interesting though such lists be, but the conditions of which they stand as the visible sign. Not catalogues of fossils, nor sections of wells, save as they speak of mineral resources, of what may be called the unutilized wealth of the State. This material should be furnished to the State Geologist for proper correlation and use. The Academy has enough work of other character, of equal value to turn all of this material over to the State Geologist.

These facts in the hands of individuals are practically valueless, usually travelling into a swift and secure oblivion through the columns of a county paper or the introduction to a county atlas. In the hands of the State Geologist these same facts would often prove of supreme importance, saving weary hours of study and laborious trips of investigation. Within the year such a wealth of facts concerning the resources of the State could be collected without especial effort on the part of any one person, that many conclusions could be drawn with almost absolute precision. Conclusions that would serve to develop new industries on the one hand, or prevent the useless expenditure of thousands of dollars on the other. I say it is a duty you and I owe the State—we have always owed it, but the duty is now an imperative one since the State has given official recognition to this organization.

Another duty is in the conservation of the wealth of the State. A collation of facts that will tend to the conservation of forests, to the destruction of weeds, the protection of birds and fish, the warding off of plant and animal diseases, improved sanitation in homes and municipalities, the increase of crop production. All of these are within the domain of science, and it is only through the labors of scientists that success will be achieved. No one has a higher and more profound respect for pure science than I. No one feels more deeply the truth that pure science—the theoretical, if you please—must precede the practical; is, indeed, the foundation of the practical. But if science expects to justify herself to the State, and hopes for continued recognition by the State, she must from time to time, at least, descend from the heights of pure science and mingle in the affairs of daily life. She must not always claim; she must occasionally do.

This duty of developing and conserving the material resources of the State I believe to be an imperative one, and one which, unfulfilled, leaves us culpably derelict.

But the duty of science to the State does not cease with the discovery of truth. It extends to its dissemination in a fairly intelligible language, with sufficient suggestions as to its relations to make it practically useful. In this matter, too, I claim that science has neglected manifest duty to her own injury. Either we have been held back by modesty, not usually considered an attribute of scientists, and refrained from publication, or we have sought publication in some journal of high rank in our own line of work, but of extremely limited circulation. When forced by occasion to use other media for relieving intellectual congestion, the articles so bristle with technicalities and multiplied allusions to German and French and Russian and Italian authorities that the hopeful neophyte turns pale and the man of affairs, eager to see what science has in store for him, turns away in disgust. As a rule, when called upon for a popular presentation, a primer style is adopted, from which an intelligent public turns with equal disgust. That the statements of science in certain presentations must have technical precision no one questions, and these presentations have their place in technical journals; but surely, after the technical language has been stripped off, and the curves of this and that and the other have been eliminated; when the foot-notes have all been dropped and the ready familiarity of the author with all languages lost sight of, there should be some small residuum of truth capable of interpretation into every-day language. It is this residuum of truth, clearly put, with relations definitely stated, that science should disseminate. It is this that will give standing and credit among the people, and until such credit is gained scientists will find themselves hampered at every turn by the wearisome iteration, impractical—theoretical. It is this dissemination of a true science in a popular, not puerile form, that is needed above all things. It is needed that our citizens may have a knowledge of all that class of facts which intimately concern their daily life, that they may know the limitations nature has placed about their efforts—may know the possibilities she opens before them; that they may have awakened in them the knowledge that through their efforts and observations new truths may be discovered which will become the heritage of their children. I am convinced that scientists have much to answer for because of this failure in duty. I am equally convinced that they have been repaid doubly for all of their sins of omission, in the almost universal lack of appreciation of the character and importance of their work. This accurate popularization of scientific truth is absolutely necessary if our work as scientists and as an Academy is taken at its full value. Did you ever think of it? Appropriations for proceedings of societies of horticulture, of agriculture, of swine-breeders, of chicken raisers, of bee-keepers, of tile-makers, without question, but grave doubts as to the publication of the

proceedings of the Academy of Science because of lack of practicality! If there is one practical thing in these days of ours it is science; if there is one form of truth which more than all others underlies and pervades all our industries, it is scientific truth; if there is one form of knowledge which more than any other seems to condition public prosperity—even to condition duration of life—it is scientific knowledge. It is a startling commentary on the neglect of duty of men of science that in these last years of this century of scientific achievements, achievements which year by year become more marvelous, more wide-reaching in their effects; when achievement seems only limited by man's daring, to hear solemn discussion as to the practical value of scientific publication. The truths of science that are fundamental, the practical application of these truths, should be the common property of every man and woman, of every school child, in the State. The scientist should be nature's interpreter to the people. Too often he has merely striven to interpret himself to others of his kind. I repeat that this Academy as a body, and through its members, owes the duty to the State of disseminating scientific truth in a straightforward, clear-cut way, that the people may have put into their hands all of the truths of science which have immediate practical bearing. If a man who accumulates money hoards it he is a mean man, a miser. The man who accumulates useful knowledge and hoards it is infinitely meaner than the miser.

Among the best intentioned educational movements in secondary schools during the last few years has been that which has introduced nature study into the grades. Following the letter of the recommendation of the committee of ten, the spirit of the recommendation has often been utterly overlooked. Nature study has been so associated with language and number and form studies that nature has flown out of the window, while number and language and form remained. Where the intention is most honest, the work is imperfectly co-ordinated, without sequence, practically without purpose. The real aim of scientific study seems often utterly misconceived, for science work consists not in the mere collection and pigeon-holing of facts, but in the development and strengthening of certain specific intellectual powers. It is evident that this state of affairs exists because scientists have not sufficiently concerned themselves in the movement to bring it success. A movement which promises so much for the symmetrical intellectual development of the youth of the State, which promises so much for science itself, is surely of sufficient importance to merit some attention from every true scientist and systematized and wisely directed efforts for its success by this Academy as a body. My position is, that this Academy should stand for the combined wisdom of its members in all matters scientific which pertain to the

common weal, and that its views in all such matters should be so voiced as to carry the influence such combined wisdom and experience merits. I believe, then, that as individuals, and as an associate body, we owe a definite duty to the State in the wise fostering of all efforts to increase the amount and improve the quality of the science work in our secondary schools. It may be urged that all of this is beyond the province of this body. As I conceive the province of science, however, such duties as I have indicated seem the most natural and forceful way of showing, even to the veriest gradgrind, the very close and eminently practical relationship existing between science and the State.

All I have said implies that the scientist recognizes himself as a loyal citizen of the State in which he works, and that he is as jealous of her honor, as careful for her prosperity, as watchful over her interests as the man who edits a newspaper, who practices law or runs for office. But where the monastic idea prevails, where the laboratory so absorbs that he loses sight of his citizenship, he is derelict in duty and discredits science.

On the other hand, the State, through her legislators, may be said to owe certain duties to science. One of the most patent of these is official recognition of the value of scientific work to the State. From the days of the New Harmony Settlement, when Indiana was the Mecca of all the Scientists of the land. when the Owens and Say and Lesquereux and others were not only revealing the natural wealth of the virgin State, but were adding lustre to her intellectual record, down to the present time has science and the scientist done much for the State. The exploitation of our coals, of our stone quarries, of our clays, of our forest resources, with the development of the industries dependent upon them, has been based directly upon the work of the scientist. As the result of the study of farm products, of plant and animal diseases and their remedies, of soils and fertilizers, thousands of dollars annually have either been saved to the State or added directly to its wealth. In manifold ways, without withholding, has science given largely and liberally to the State. It would seem but a natural thing in view of such a record for the State to assume that science still had something in store for her; to assume that when she spoke her utterances would have value. It would seem but a just thing when the scientists of the State are associated together and have organized definitely for an increase of knowledge of the resources of the State to at least provide for the publication of this knowledge. It would seem to be the high-water mark of practicality as well as economy to secure something for nothing. The worker has the satisfaction of work well done, the State all the results of his labor.

Points of view vary, however, and what may seem just and generous to the scientist, may not have such a fair seeming to the legislator. But I believe that an honest and intelligent study of the contributions of science to the material wealth and intellectual development of the State will furnish a sufficient warrant for the views advanced.

The obvious way in which this official recognition could be given objective form is in a permanent appropriation for the publication of the proceedings of this Academy—an appropriation sufficiently liberal to insure the proper presentation of its work. The expense would be most trivial compared with the results such action would secure. Results which would extend beyond the material and would powerfully upbuild and support the educational system of the State. It seems to me that a failure to utilize such an agency is inexcusable. I believe that if there were no material interests involved, the proper encouragement of scientific investigation, regarded from a purely intellectual standpoint and because of its reflex influence upon the character of the instruction in the secondary schools, is within the province of the State and may fairly be classed as one of its duties. The history of such action and its results in other States serves to emphasize this view. I am not, however, so much interested in the duty of the State to science as in the converse, and feel in nowise moved to instruct legislators in their duties.

If, however, there is a full recognition of the mutual obligations existing between science and the State, then the organization of this Academy opens wide the gate of opportunity.

Before suggesting these opportunities, allow me to say that I believe that, perfect as is our organization, it can be made far more productive of results by a proper co-ordination and distribution of work. There are certain investigations which can not be made by individual workers which can easily be carried on in the laboratories of the colleges. There are other investigations which can only be carried to a successful conclusion by the co-operation of many persons or in some cases of several colleges. It is one of the most difficult things in the world to recognize the limitations our environment imposes upon us, but a failure to recognize such limitations leads often to a sad waste of energy. To properly utilize the energy of the Academy there should be a co-ordination of the scientific work of the State of such a character as would at least prevent overlapping and valueless repetition, as would give the individual worker his proper field, thus freeing the larger laboratories for the broader problems demanding for their solution large equipments and libraries. Apparently, the only thing that stands in the way of such co-operation and such a practical distribution of work is the desire most of us have to pose as past masters of science. Is it too much to say a

feeling of jealously, a fear lest some other worker will gain more of reputation or popular favor? I much fear me that were we fully truthful with ourselves some slight leaven of professional jealousy might be found working in our actions. It seems clear to me—very clear indeed—that before we can properly seize the opportunities offered, there must be some practical, though not necessarily formal co-ordination of work.

Take the opportunities. for concerted, co-ordinated work in a single science and notice how great their practical as well as theoretical value. There are certain natural resources of the State which may be materially developed in some instances, or have their utility greatly increased in others, by full and complete chemical studies. Perhaps that of the greatest importance from a commercial standpoint is the thorough and complete investigation of the clay deposits of the State. I will be pardoned for saying that I think that the last volume of the Geological Reports fully justifies all the grants ever made to the survey by the preliminary investigation of the clay deposits of the coal bearing counties. The certain outcome of the work is the rapid development of new industries, based upon this formerly unutilized resource, which will annually produce thousands of dollars in excess of all appropriations ever made for the survey. But this investigation has but begun, and a full knowledge of the clay deposits will only be possible after many years, unless there be in the various laboratories of the State full and complete studies made of the possibilities of these clays in various directions. Some are fitted specially for tile, some for paving brick, some for building brick, some for pottery, special uses which can only be determined by studies in the chemical laboratory or by the costly experiments of actual manufacture. From work of this character would naturally follow monographic work upon the chemical problems involved in the successive steps in the manufacture of each of these various products. Such work would give almost immediate return and would appeal to a much larger constituency than the scientist can usually hope to reach.

In the line of increasing the utility of resources already developed, it is evident that chemical investigations would reveal many ways in which our coal and gas and oil might be made to yield even richer returns than at present.

That an intimate relationship exists between public prosperity and public health is no longer questioned. It is a matter of popular knowledge, which is taking form in the various voluntary and legalized organizations for the improvement of sanitary conditions in homes and municipalities. This movement suggests another opportunity for concerted chemical work bearing upon these grave problems. No more valuable work for the State could be carried out than that of

a chlorine survey of the natural waters of the streams and springs of the State. A knowledge of the local normal chlorine in the natural waters of the State is almost a necessity, if outbreaks of disease are to be anticipated. Any sudden increase in the amount of chlorine in a given locality, would give warning of possible danger and serve to give direction to the efforts of health officers in averting disease from their districts. A chlorine map of the State is a necessity for its proper sanitary control and this work can only be done satisfactorily and rapidly by the concerted work of an organization, such as this Academy. After the establishment of this chlorine base line there would still be necessary the regular examination of water supplies for purposes of comparison, which could be done in almost every case by the local health officer. Without this base line chemical analyses of water lose much of their meaning.

Correlated naturally with this would be the general examination of water in epidemic districts, the immediate benefits of which are self-evident.

The mineral waters of the State open another field of chemical research work, attractive and of evident value. It is manifest that in the working out of problems, such as these, covering the whole area of the State, there should be the most careful co-ordination, the most perfect division of labor. It does not seem to me that such work is beyond the province of the Academy, indeed it seems to be its supreme province so far as its relation to the State is concerned.

Since I am speaking of chemical research, allow me to suggest that much yet remains to be known of the chemistry of the soils and rocks of the State, much that must be known if in the near future we reach the apotheosis of usefulness, which some one says consists of making two blades of grass grow where one had grown before.

The plant world also offers to chemistry opportunities for investigation in lines not merely of theoretical interest, but of high practical value. The examination of vegetable products—for example, of plants producing sugar, tannin, medicinal properties, etc. How much of unutilized wealth is at our feet, bound up in plants, only waiting the word of science for its release. It is said that one of our smart weeds (*Polygonum amphibirem*), a common plant in marsh regions, contains 18 per cent., by weight, of tannin[1], an amount sufficient, if the statement is true, to justify at least an attempt to utilize it for commercial purposes. This is but an illustration of scores of cases which might be cited to show the possibilities of this form of work.

It is strange when we consider the length of time scientists have been at work in the state, that there is so little of actual knowledge concerning its topographical

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[1] Bot. Gaz., vol. i, p. 20.

features, and, stranger still, of its drainage systems. In a general way we recognize the lowlands of the State are located in the southwestern counties, while the highland regions, if they can be dignified, are in the eastern-central counties; we know there are chains of hills in the south and prairies in the north, but beyond these facts we know very little.

We are familiar with the two great drainage systems of the State, but of the minor details essential in the working out of local problems we have absolutety no data—at least none that are at all available. In an attempt last year, in the sanitary laboratories at Purdue, to make a contour map of the State, the paucity of data was strikingly apparent. Had it not been for the railroad levels, not even an approximation could have been reached. It is not necessary to say more than that a moment's reflection will suggest the far-reaching application and value of this work. It is also manifest that the accomplishment of such work is only possible through the intelligent co-operation of the members of a body such as this.

I have purposely omitted thus far any mention of the opportunities that open to biologists. From my point of view they are so numerous and of such importance that they are almost self-evident. Fields that have already been entered show themselves broadening as the work advances. And the work already done suggests yet further worlds for conquest. The biologist still has much to do in the line of plant and animal diseases, infinitely more in the line of sanitation. The accomplishment of yesterday in these lines serves merely as the incentive for the work of to-day. There is little danger that work of this character will be neglected. There are, however, other problems, the solution of which depends upon a patient gathering of facts almost innumerable, and an equally patient study of these facts in their true relations—problems which by their mere statement carry little idea of their real importance. Systematic botany has, I presume, in the opinion of most people, about as little to do in the realm of practical affairs as any branch of knowledge. Such an opinion is doubtless true if systematic botany consists, as is the popular conception, in the mere cataloguing and naming of plants. The systematic botany of to-day is, however, far more than this; it involves studies of plants in their relations to soil and rainfall, to heat and light, to air and mechanique, to each other, to animal life. More and more clearly out of the great masses of facts being collected in ecological studies is the truth becoming apparent that plants stand as the sure sign of the natural agricultural capacity of the soil upon which they grow.

Allow me to quote from Mr. Corille's "*Botany of the Death Valley Expedition*," a report, which is a model in every way. After showing that trees and shrubs

are most reliable as zonal guides, he says: "Shrubs and trees, being commonly larger than herbaceous plants, reach higher into the air and penetrate more deeply into the soil, thereby subjecting themselves to a wider range of conditions than do these smaller plants. They also, by continuing throughout the year exposed to successive, varying seasonal conditions, complete the full round of their possibilities in environment. They therefore stand as the most complete summation that can be attained of the natural light, heat, moisture, food, air and mechanique of any area; in other words, a sure index of the natural agricultural capacity of the soil upon which they grow. From a utilitarian point of view, too much stress can scarcely be laid upon this fact. It has been the practice of agriculturists to gauge the capacity of soils, in regions new to the plow, by observations on rainfall, temperature, cloudiness, chemical composition of the soil, drainage, and many other phenomena, or by the even more laborious process of experimenting on every farm with each kind of cultivated product; ignoring the fact that this determination can be greatly hastened, cheapened, and authenticated by correlating the natural vegetation, especially that made up of the trees and shrubs, with that of other regions, whose agricultural capacities are known."[1]

A careful gathering of facts of the character indicated regarding our native flora would not only give results of the highest practical value, but would also serve in a great measure to relieve chemists and agriculturists of irksome work, the results of which at best could be of but local value. In this broader view even systematic botany has opened before it a splendid opportunity, for I know to my sorrow how few facts of this kind are available. Here, also, it is evident that data sufficiently extended can only be secured through intelligent co-operation of botanists throughout the State. No more attractive field offers; none in which the prospect of valuable returns is more promising.

A recent article in *Nature*, by M. T. Masters, abstracted in the *Popular Science Monthly* for October, 1896, on "Plant Breeding," is also suggestive of work of great practical value along botanical lines. Quoting briefly: "The natural capacity for variation of the plant furnishes the basis on which the breeder has to work, and this capacity varies greatly in degree in different plants, so that some are more amenable and pliant than others. The trial grounds of our great seedsmen furnish object lessons of this kind on a vast scale. The two processes (selection and cross-breeding) are antagonistic. On the one hand, every care is taken to preserve the breed and to neutralize variation as far as possible, so that the seed may "*come true;*" on the other hand, when the variation does occur the observation of the grower marks the change, and he either rejects the plant,

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[1] Botany of the Death Valley Expedition. 18

manifesting it as a "*rogue*" if the change is undesirable, or takes care of it for further trial if the variation holds out promise of novelty or improvement. Where the flowers lend themselves readily to cross-fertilization by means of insects, it is essential, in order to maintain the purity of the offspring, to grow the several varieties at a very wide distance apart. Some apparently slight variations, which, even to the trained botanist, are hardly noticeable, may be of great value commercially – as, for instance, of two apparently almost identical varieties of wheat, one may be much better able to resist mildew and diseases generally than another; some again prove to be better adapted to certain soils, or for some climates, than others; some are less liable to injury from predatory birds, and so on. So far we have been alluding to variations in the plant as grown from the seed, but similar changes are observable in the ordinary buds, and gardeners are not slow to take advantage of these variations. The field is one of great scientific as well as commercial interest, and a thoroughly equipped biologist would probably soon distance the ordinary gardener who works by rule of hand in producing and perpetuating valuable variations."[1]

This audience will carry the thought of opportunity into other lines of scientific work without additional detail. The zoölogists are hard at work, under careful organization, and will at this meeting show something of the scope of their work, with the results already reached. The engineers, with all their energies, have as yet been unable to fully occupy their territories, so manifold are their fields for investigation.

All that I have suggested involves no neglect of pure science. Neither does it necessarily involve the abandoning of work which, with our present knowledge, seems purely theoretical. It does not suggest the introduction of the mercenary or utilitarian idea into scientific work. It is only an intimation of how, by a judicious and well-ordered treatment of what may be called the by-products of our activity much good may be accomplished for science, much for the State. As the manufacturer often finds that the careful utilization of the by-products conditions success, so the scientist may find that his success depends upon his contributions to the general good. Every truth will, of course, at some time take its appointed place and be assigned its true value; but many truths of science as yet stand isolated—unrelated, marvelous products, often, of skill and patience, but, until they find their true place, of little general interest. Through facts such as these scientist may appeal to scientist, but it is through simpler facts of readier application that science appeals to the State.

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[1] Pop. Sci. Monthly, Oct., 1896, pp. 859–860.

I have thus in the broadest lines indicated what seemed to me some of the evident duties of the Academy to the State, and what seemed to be opportunities for increasing its value to the State. All are dependent upon the combined work of many individuals. Few, if any, can be accomplished save through an organization such as this.

I look over the secondary schools of the State and find that the teachers of science, with few exceptions, are poorly paid; that science courses are, almost without exception, arranged with reference to recitation schedules rather than to logical sequence of subjects or intellectual capacity of pupils. That science is assigned a value in the curriculum far less than language, or number, or form. I find in our colleges, again, with few exceptions, that while it is not expected that one man can teach both Latin and Greek, it is expected often that one man can teach Botany, and Zoölogy, and Physiology, and Chemistry, and Physics, with other incidental subjects to fill his schedule. I find a prevailing belief that the scientific specialist is a narrow man, when, by the very nature of things, he must be, if a true specialist, one of the broadest of men; a belief, in general, that science is impractical, theoretical, visionary. All this in spite of the fact that far more than any other force has science directed—yes, dominated—the progress of the past decades. I believe the cause of all this to be that science has not been fairly dealt with by her devotees. That the scientist, absorbed in the work of the laboratory, has too often forgotten his citizenship and neglected to transfer to the State the truth which science had placed in his hands. Primarily the objects of the Academy are inspirational, but secondarily, at least, and certainly in its relations to the State, its objects should be eminently practical.

If we fully grasp the idea of this relationship, which I have but imperfectly outlined, the possibilities of science in Indiana are almost limitless. Its influence will be increased, its constituency broadened, its achievements more splendid, and the prophecy of a high place in science, born in the New Harmony days, will have its realization in the effective and beneficent work of this Academy.

The Evolution of the Map of Mammoth Cave, Kentucky. By R. Ellsworth Call.

There probably does not exist elsewhere on earth so famous a natural feature concerning which so little is definitely known as the Mammoth Cave of Kentucky. Its scientific exploration has been so hampered and guarded by a jealous fear of rival interests that no one has been permitted to survey the great cavern and to

project it on the surface in order to determine its relations to the topography of the region in which it is located. There have been but few attempts to so delineate its hundreds of ramifications that the visitor may know his whereabouts by reference to surface features. These are commonly conjectural; the guides profess to have, and for the most part are honest, but little knowledge of the relations of the outdoor topography to that of the avenues and chambers of the cave. The liberal management of the present Superintendent, Mr. Henry C. Ganter, extended to the writer in a hundred different ways the most complete opportunities to examine and study the cave in the usually inaccessible localities as well as those commonly visited. Measurements and compass work was permitted within the cave but the line was drawn when surface work was planned or attempted. Courtesy freely extended must be regarded, and while the results attained are not of the most exact kind, nearly four years of exploration have given a better idea of its surface relations and internal ramifications than could otherwise have been possible.

The interests of the present owners are as jealously guarded as ever, and in this communication, therefore, I shall not violate any confidence which has been vouched to me. Nevertheless, I can not refrain from placing on record, in this manner, my firm belief that a survey which has been made ought to be projected in map form and given to the world of science. Only good could result to all the interests involved should an accurate knowledge of the cavern's relations to the surface be made public. Such information would be invaluable to one who wishes to know the great cavern as a geological entity. Perhaps, as the years roll by, wiser counsels will prevail and the world will eventually know Mammoth Cave in all its ramifications and will see them represented on a map which will also show their relations to the surface. For the present it is my purpose to give a history of the several published maps, and the manner in which they have been prepared, to show how difficult has been the process of evolving the map and to emphasize the present need of a cartograph which shall exhibit the cave as it is.

Mammoth Cave was discovered through an accident of the chase in the year 1809 by one Hutchins, a hunter who, tradition says, traced a wounded bear to the entrance, then quite hidden in a dense growth of underbrush and fallen trees. It would be difficult to imagine a more rough and wild region than is the country in which this greatest of caverns is situated. Facing north, on the side of the Green River Canyon, far away from the traveled routes of the olden time, accident only could have brought it to view. If Hutchins ever really lived there now remains no trace of him beyond the tradition of discovery; none of his kith or kin have been discovered in the region. Perhaps with this single act to make him forever

known he was content to pass from human view. In those good old Kentucky days, when firearms were as much in vogue as they are in these later days, and with worthier ends be it remarked in passing, gunpowder was a scarce article and was husbanded beyond comparison. A roving Philadelphia chemist, Dr. Samuel Brown by name, first taught the earlier settlers the methods of manufacture of gunpowder, with probably as great acceptability as Latinus first taught the Latins agriculture. But the nitre-bearing sheltered cliffs and caves of the Blue Grass region could not alone furnish all the needed nitrate, originally obtained in the form of calcium nitrate, from which the needed saltpetre, or potassium nitrate, was procured through the medium of wood ashes in the clumsy chemistry of nearly a century ago. Recourse was therefore had to other caverns, which were assiduously sought after and many found. From these the needed nitrate was obtained in abundance and a great industry was built up in Kentucky. Rumors of the great cave in Warren County, for we may be sure that coupled with the growth and size of that famous bear each time the story was recounted, Hutchins did not fail to tell of the cave he had found, reached the ears of the middle Kentucky folk and business enterprise soon made Mammoth Cave a fact of history.

Mammoth Cave appears to have attracted great attention from the very first, though its chief value seems to have been connected with the manufacture of saltpetre. When the war of 1812 came and the resources of the United States were taxed to the utmost in securing materials for the making of powder because the foreign supply was rendered uncertain through the exigencies of war, the caverns of Kentucky furnished nearly all the saltpetre used in that memorable conflict. With central Kentucky, and notably with Lexington, the great eastern city of Philadelphia had intimate commercial relations. It resulted that the caverns of this portion of the State soon were exhausted of their precious nitrate and the new, stupendous Green River cave came prominently into view. A Philadelphian of Hebrew descent, and a patriot, by name Hyman Gratz, associated with one Charles Wilkins, of Lexington, leased Mammoth Cave from its earliest owner and carried on in extensive scale the manufacture of saltpetre. Many tons of "petre-dirt," as the miners called it, were brought from far within the cave, the places where they last dug and the vats in which they leached the earth still attesting the magnitude of their operations. With the development of this industry came visitors, and with the visitors went wonderful stories of the great cave. It thus happened that in August of 1814 a gentleman unknown to later days wrote an extended account to "a respectable gentleman of New York," which was published in the *Medical Repository*, then under the editorial control of the eminent Dr. Samuel Latham Mitchill, accompanied by a map. The account

and map appeared in the seventeenth volume of that journal. It is presented herewith, not because it has value as being an accurate map of the cave, but because it possesses a certain archaic value as being the first map to have appeared in print. A previous map, essentially the same, is known to have been made, but there is no record of its having found a way into literature. The author of our map is unknown, so far as any fact connected with its publication goes, but in a later number of the same journal another map is mentioned as accompanying a description of a mummy from a cave near by and on deposit for exhibition purposes in the Mammoth Cave, and is said to be the same, substantially, "as that which we had received before from Mr. Bogert;" from which fact it appears that such was the name of the man who presented the original map. But nothing more is known of him. This map is not drawn to scale, nor was the compass employed in determining the relations and directions of the several halls. With the exception of a very few localities near the entrance, which are fairly correctly located, it is impossible to identify any of these avenues with those now known. But the map is important as being the beginning of the published cartography of the cave.

The second map of Mammoth Cave was the one prepared by Dr. Nahum Ward, a photographic copy of which is presented herewith, its original, the only copy now known to be extant, being in my own library. This map first appeared in the Worcester *Spy*, a newspaper of Massachusetts, in June or July, 1816. My copy is a *facsimile*, printed on one-half of a newspaper sheet, with blank reverse. As presented herewith it is reduced one-half.

As in the case of Bogert's map, so in this one, it is impossible to identify very many of the localities mentioned. The descriptions of Doctor Ward are quite full but are by no means exact. He appears to have been thoroughly impressed by the great magnitude of the cavern, and the terms selected to convey his ideas of the cave comport well with its greatness. But the map is drawn to no scale and, as may be noted from the map itself, its horizontal distances are grossly inaccurate. In addition this writer makes the cavern to pass under the Green River in three separate places. As a matter of fact it is impossible for such an extension to happen; the area of the cave is limited by the configuration of the country around it; while its depth is determined by the level of Green River, into which, by several separate channels, breaking out as large or small springs, the waters of the cavern eventually find their way. The drainage levels of the subterranean streams are all determined by that of the Green. While Ward employed the compass at places and determined thus the directions of the longest diameters of the great halls, he did not employ it constantly or systematically and nowhere did

he run long lines or have points for "tying" those he did run. His published account is the first extensive one in literature, though it, like all the earlier ones, abounds in exaggerations.*

The next map, in order of publication, bears the date of 1835, the year of its copyright, and was prepared by Edmund F. Lee, a civil engineer of Cincinnati, Ohio. It is based upon the first instrumental survey ever made of the cave, and is both complete and accurate for that portion which may be called the cisriparian cave. The rivers and all that vast area of the cavern which lies beyond, were then unknown and undreamed of.

The rivers were discovered by Stephen Bishop, the guide, in the year 1840, for the way to them, over what is now the Bottomless Pit, had not been known; the Pit itself was not crossed until 1840, the crossing being almost immediately followed by the discovery of River Hall and all its wonders. Consequently none of this portion of the cavern appears in Lee's map, a copy of which is herewith given, from a faded copy in my library, which, like the others mentioned, is the only copy now known to be in existence. Lee's map is further characterized by sections of the several known avenues and chambers, and is the result of many month's of underground work. As laid down in his map the relations of the avenues and chambers are absolutely accurate; the nomenclature has since very greatly changed, as the fancy of visitors or the caprice of the several managers have dictated. It will be at once recognized that this map has extraordinary value when it is stated that it forms the basis of several other maps which have appeared from time to time; further, it is the first map to have been professionally made. Complete surveys of most of the newer or transriparian avenues have never been made. Some of these avenues and passages, like that which leads to Mystic River, leaving El Ghor just below Martha's Vineyard, have been entirely closed up by the management and never will be surveyed. A complete map of the cave will, therefore, always be impossible, and some avenues will only

*Since this article was completed, chance has thrown in my way an old volume published by Lee & Shepard, Boston, in 1873, "The Wonders of the World," which reproduces Ward's account of Mammoth Cave, together with his original map; the map appears as page 327 and has a cut of the "mummy, now in the American Museum, New York." It is interesting to note that this old map is useless in such a book. It is further interesting to note that the mummy was not then in the American Museum, nor ever had been, beyond a few days for exhibition purposes, but was deposited in the museum of the American Antiquarian Society, at Worcester, Massachusetts. A short time since, following the World's Fair, where it was on exhibition, it was removed to the National Museum, at Washington, where it may now be seen. A most excellent photograph of this famous mummy was recently made for me and forwarded by the courtesy of the late Dr. G. Brown Goode. The account of the cave, which this volume gives, in 1873, is a verbatim reproduction of Nahum Ward's original description, made in 1816. In this way do great publishing houses give us new and fresh knowledge of the world's wonders.

have historic names. They will never be visited by future explorers. But Lee alone has surveyed the intricate and devious windings which make up the Labyrinth, together with its associated chambers. Use was made of his work by the maps which followed.

The parts of the cavern which are beyond the pass known as El Ghor, including a considerable portion of explored but unmapped cave, have had several names bestowed on them by the earlier visitors. Of the parts which it will now be impossible to visit, owing to the artificial occlusion of the small passage under Martha's Vineyard, are the following: Byrd's Avenue, Miriam's Avenue, Harlan's Avenue and Hebe's Spring. The Mystic River itself rivals the famous Echo River, but is less in size. It has probably some connection with Roaring River, a great stream at times, reached from Stephenson's Avenue at the Cascades, but as yet unexplored fully. Several attempts made by the writer to reach its end were defeated by lack of boats, the only means by which the deeper and unfamiliar places can be passed.

Lee's map was followed by one prepared from accounts and free-hand sketches of Stephen Bishop, in 1845, and is found in a little volume called "Mammoth Cave, by a Visitor," and published by Morton & Griswold, of Louisville, Kentucky. This map appears to have Lee's map as its basis for the older portion of the cave; the newer portion, which had not then been surveyed, is laid down by Bishop and from his notes. In common with all the published maps of later date than Lee's, the distances are grossly exaggerated, and the relations of some of the avenues are certainly hypothetical. But this map stands to-day as the best that has been published, and while inaccurate for any scientific purpose is certainly exact enough for the visitor. It names and shows the points of departure of the side avenues from the larger and better known or more traveled portions and gives a sketch of their turnings and ramifications. It is to be constantly remembered that none of the maps, except Lee's, have been based upon compass bearings, even, to say nothing of determining their relations by exact methods.

No other map appeared until 1875, when Forwood's "The Mammoth Cave of Kentucky," Fourth Edition, appeared from the Lippincott press, of Philadelphia. His map gives only the two traveled routes, called the "long" and the "short" routes, and is grossly inaccurate even for these. No dependence can be placed upon any of the details of this map. It is noticed here simply because it is one of the few which have ever been published.

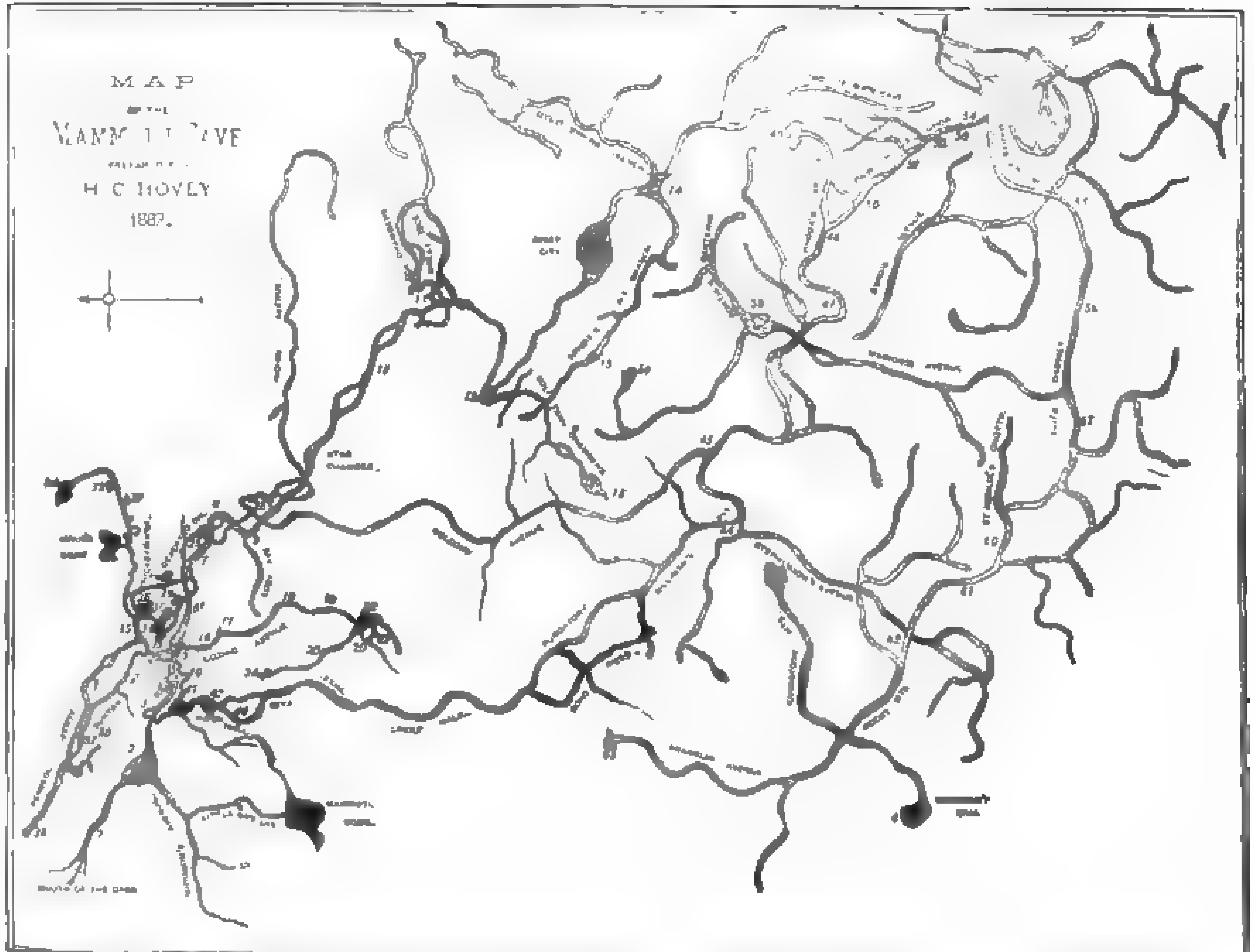
Hovey's map, which appeared in his "Celebrated American Caverns," in 1882, is the next in order of time. It is probably the best known map of the cave having been reproduced in a number of other publications and been sent abroad

in numerous copies of his guide book, itself a separately bound excerpt from the larger volume, with slight changes in the later editions. This map is chiefly that of Bishop; all the main features of Bishop's map appear and few additional facts. For the older portion of the cave, like Bishop's map, this one follows very closely the original work of Lee. No mention is made of these sources, and Doctor Hovey did not himself map any part of this great cave except Ganter's Avenue. Some measurements of separate localities were made by him, but beyond this his map has very little original matter or matter not already known. It is, however, a useful one, for more names to localities appear on this map than on any other, many of which have been happily bestowed by Hovey who, in these matters, has appreciated the "eternal fitness of things." In his names record is often made of the pioneers of discovery in the cave; in other cases he has happily made allusions to mythologic characters to which is added the uncanny suggestiveness of the gloom of the underground world.

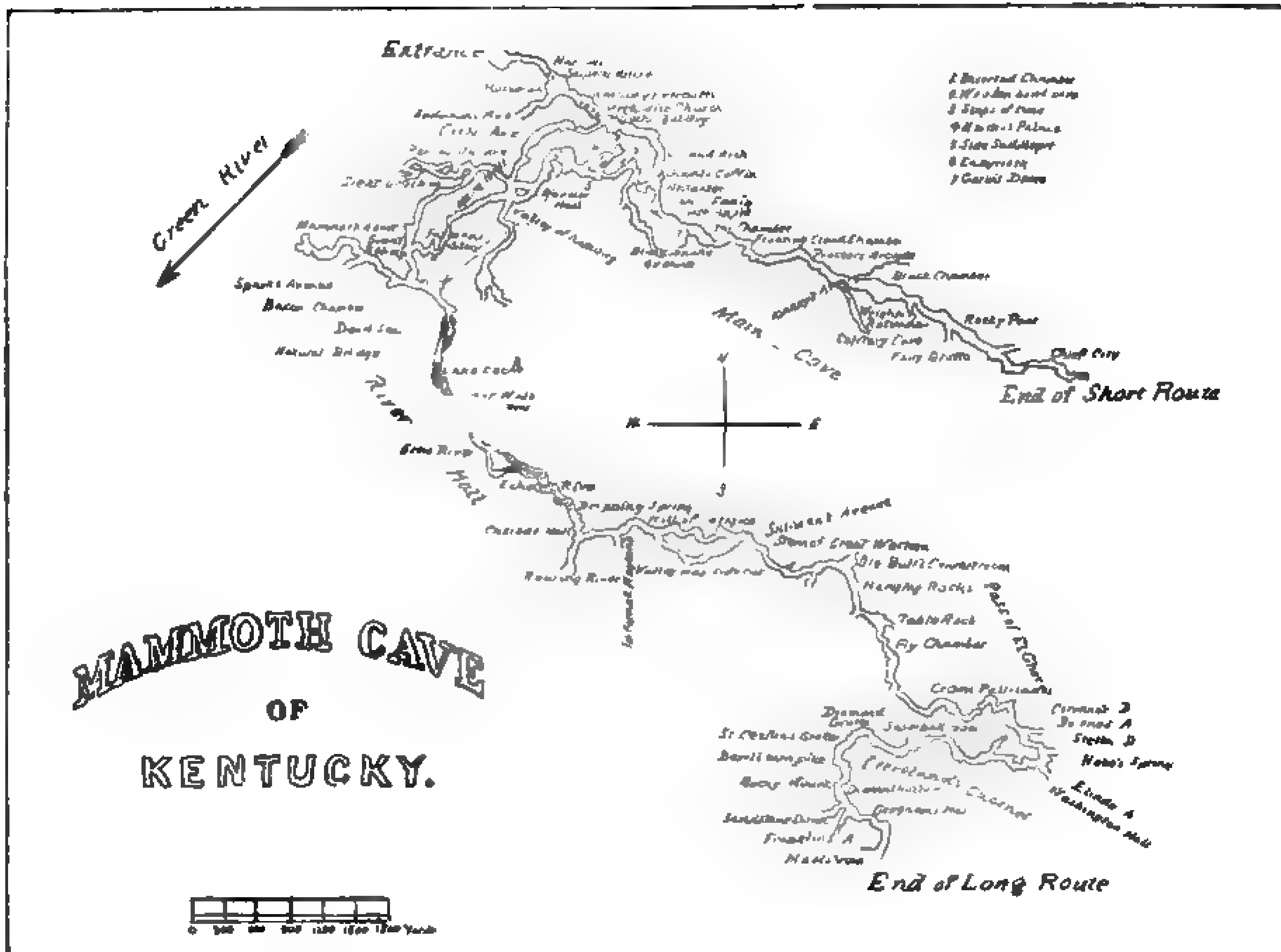
The latest map of the cave is still unpublished, but will appear within a few months. In it the attempt will be made to correct the errors of the older maps and to add to them as wholes the newly discovered portions or those portions of which little has hitherto been known. But when this map shall have appeared it will demonstrate the need of accurate surveys, which are never likely to be made, rather than add very greatly to our knowledge of the cave. Still, errors of others being corrected, the golden goal of exact knowledge will be brought a very little nearer.

It is well known that the main avenues of the cave have been "run" by competent engineers, and they have been platted on the surface, in part at least. This was done in the attempt to learn whether any of the more valuable parts of the cave extended beyond the limits of the present "cave estate." No one has been allowed to see these plats except those who are directly interested. The closeness with which this information is kept argues for the fact that without doubt the cavern extends beyond the estate. Numerous attempts have been made to find other entrances than the one on the estate; that they exist is proven by the free circulation of the air and the presence, in places miles from the well-known mouth, of seeds and leaves, sticks and bark, from the surface, and oftentimes in a fairly fresh condition. But these entrances are small and not likely to ever prove valuable to others if found. It is this fear of attempts to enter the property of the present estate that operates to make impossible, at present, a cartograph which exhibits Mammoth Cave in its true relations to the region in which it is situated.

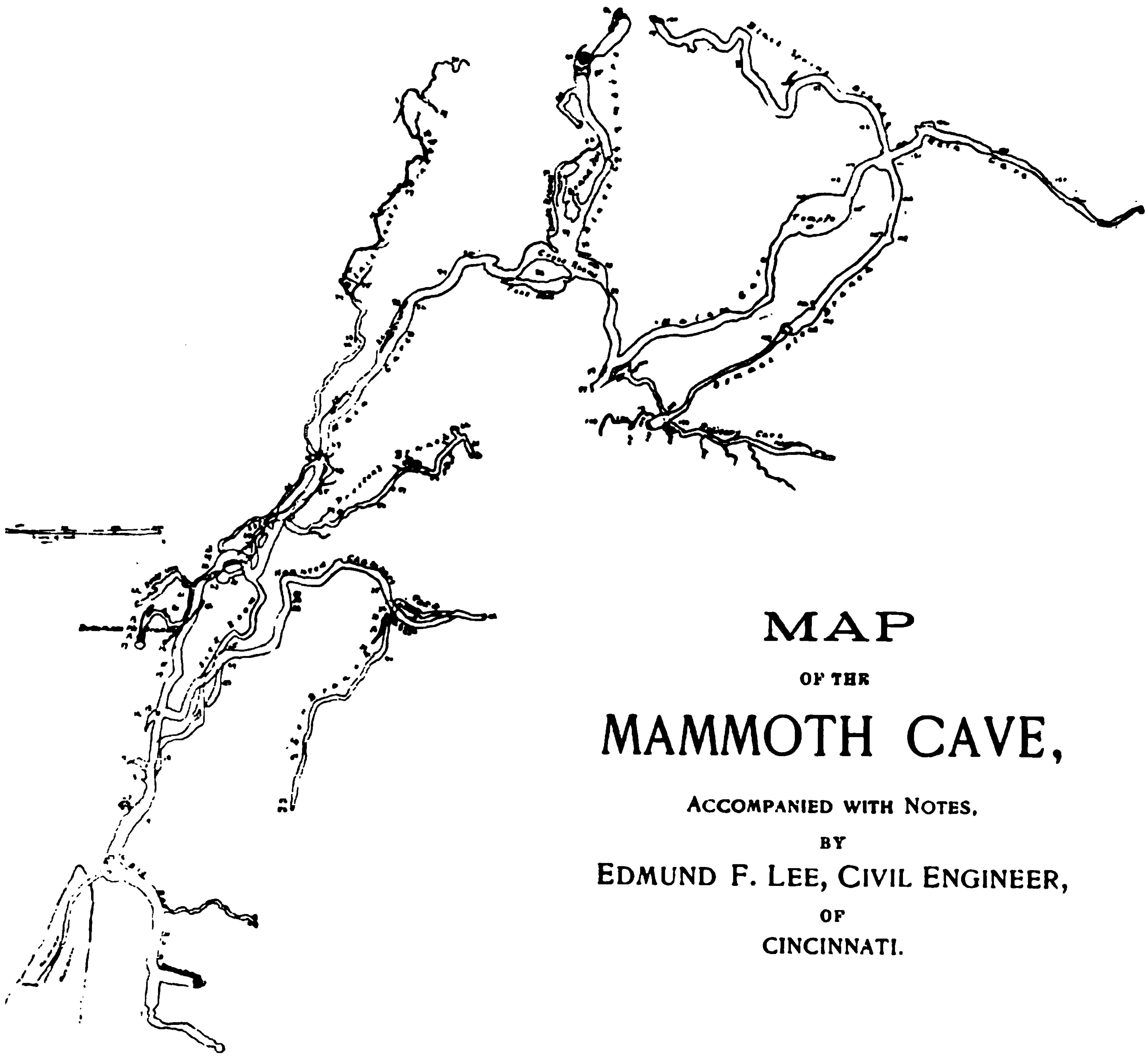
Fig 1
Bogert's Map.
1814.



MAP
H C HOVEY



Forwood's Map, 1875.



MAP

OF THE

MAMMOTH CAVE,

ACCOMPANIED WITH NOTES,

BY

EDMUND F. LEE, CIVIL ENGINEER,

OF

CINCINNATI.

Fauna of Mammoth Cave, Kentucky. By R. E. Call.

Published in the American Naturalist, May 1, 1897.

Notes on Indiana Caves and Their Fauna. By W. S. Blatchley.

Published in the State Geological Report for 1896.

A Possible Relation of the Academy of Science to the Teachers of Biology in Our Secondary Schools. By L. J. Rettger.

[Abstract.]

The purpose of the Academy of Science, as I understand it, is in the main two-fold. It aims to encourage original research work among its members, and so enhances the amount of scientific knowledge by valuable contributions. It also encourages younger observers to attempt more critical work and so prepare to continue the regular research work. By its organization and its meetings it is able to accomplish this to a very satisfactory degree.

The second purpose is probably the dissemination of scientific knowledge among the people. It is this second purpose that makes the first one peculiarly valuable to the State, and in the fullest way repays the favors which the State officially grants the Academy. But the dissemination need not be limited to the actual research work of the Academy. It may legitimately include that basal scientific information which any advanced work presupposes.

It will in this way create a more general and a more intelligent appreciation of true scientific work and may result in bringing out scientific talent that would otherwise have been missed.

The avenue along which the Academy may most efficiently exert its influence in this way is in the secondary schools of the State. By persistent efforts biological studies in some form or other are included in almost every high school curriculum and so the way is open as far as the subject matter is concerned. In many instances, too, there are teachers who have had a high grade laboratory training and who teach the subject in the high school in a most commendable way. But the fact remains that possibly in the majority of instances biological work in our high schools is still deeply mired in text book work. The utter worthlessness of biological work which does not bring the student into a direct contact with at least a reasonable number of actual things need not be restated. It is a maxim that such work is laboratory work or it is nothing.

In many instances this kind of work done is due to the lack of training of the teacher himself and for such a place there is no hope until by some good fortune the teacher gives way to a better. But there is a second class where biological work is handicapped in spite of a well trained teacher, and it is this class for which a possible remedy is here suggested. In few high schools indeed does the work in biology fall to a single teacher and occupy all his time. In practically all our secondary schools the teacher of biology has in addition to his zöology or botany classes, three or four other classes that may range from Greek through English Literature to mathematics. Usually his entire school day is occupied in "hearing" recitations. Time spent in laboratory work is usually "off time." There seems often but one thing left and that is to devote the recitation period in botany or zöology to an exposition of some text, and the actual study of things is very infrequent. If it be asked why the recitation period itself is not devoted to actual laboratory work, one needs but to be reminded that laboratory work requires material, good material, and a fairly large amount of it. And to continue this day after day with new forms means an amount of time spent in preparing this material which is not available to the high school teacher with his multiplicity of other duties. The teacher is further often quite unacquainted with the resources of his neighborhood, and is frequently not assigned to his place of duty until after the opportunities for collecting are gone. The writer has had the opportunity of visiting numbers of High Schools, and in almost all instances the apology for doing a low grade of work in botany or zoölogy was the one that specimens were, in spite of best efforts, not accessible. Sometimes the neighborhood would yield in abundance two or three different forms for study, and these would be studied as the material warranted, and yield all those desirable results which flow from the study of actual things. But these forms are soon exhausted, and the interest of the class is lost in attempts to put in the remaining time in this line of work which the program calls for.

For this difficulty it seems to me the Academy could offer a remedy. It could establish a central station of supplies from which all secondary schools could draw their material. Being controlled by the Academy, the following things would be assured in this matter: (1) Material well adapted for school work would be selected. This material could so be hardened, dried or otherwise preserved as to be in available form during any time of the school year. (2) Exchanges could be made subject to the approval of the station, and so a variety of forms secured for a collection of one or two forms which the teacher's own neighborhood easily afforded. A possibility to get a good assortment of forms without the direct outlay

of money is thus opened. As nearly every neighborhood has semething in abundance which is more or less rare in others, this plan can not be wholly impracticable. (3) Along with this high grade material the station could send carefully prepared directions for study in order to insure the proper use of the material. (4) This central station, being under the immediate control of the Academy, would preclude the suspicion that there was a mercenary element back of the affair, and would come to the teachers or school authorities with the force and influence of the Academy itself. (5) It would furnish all material to schools at actual cost, which would make the expense to equip a botany or zoölogy class through the winter a very slight one. (6) It would be a central station to which regular collectors could send the surplus of their collections for free distribution, and so materially widen the value of their work.

[Upon motion, the Chair appointed a committee to investigate the desirability of such a plan; the committee consisting of L. J. Rettger, Dr. C. H. Eigenmann and W. P. Shannon.]

THE OCCURRENCE OF UROGLENA IN THE LAFAYETTE (IND.) CITY WATER. BY SEVERANCE BURRAGE.

It not infrequently happens, even with the best public water supplies, that the attention of the consumer is attracted by some peculiar taste or oder in the water. This is particularly apt to be the case when the supply is derived from a lake or pond, or if it has to be stored for any length of time in a reservoir. In such instances the superintendent or water commissioners receive complaints to the effect that the water has a very disagreeable taste and smell, and that there must be dead fish or eels in the pipes. Just such complaints were heard in Lafayette in the early part of October, and vigorous attempts were immediately made to get rid of the trouble by flushing the pipes at different points in the city. But there was not much improvement.

The city water supply is derived from driven wells in the vicinity of the Wabash River, and is a remarkably pure water, both from the chemical and biological standpoints. This water is pumped directly into the pipes. There is a reservoir situated on a hill some two miles from the pumping station, and it has been generally understood that the water stored there was only used in case of an emergency, such as a large fire. But upon inquiry it was learned that the pumps were not kept working all night. Thus, as the supply from the pumps was stopped, the reservoir water must work back gradually into the pipes, replacing

that used in the town after the pumping had ceased. Now if the trouble was in the reservoir water, we would expect to have the complaints made in the early morning, which would be the only time, as we have seen, that this water had access to the service pipes. And such was the case. All the complaints were made in the morning, and when the superintendent would go to investigate at this or that place late in the forenoon he could detect nothing wrong in the water. The pumps had started and forced the reservoir water back to a certain extent, fresh water from the wells taking its place.

All of this evidence, together with our knowledge of the natural history or biology of bodies of water exposed to the sunlight would point to the reservoir as the source of the trouble. A microscopical examination of this water was made, and it showed the presence, among other things, of the colony-building infusorial organism *Uroglena* in small numbers.

This Uroglena is well known in Massachusetts and Connecticut as having caused strong fishy tastes and disagreeable oily smells in many large water supplies, and in some cases in the very best ones. So that knowing the history of this organism, and finding it in the water of the reservoir, it was unnecessary to search further for the trouble.

This organism itself has been described by Ehrenberg[1], Bütschli[2], Stein[3], Kent[4], and Calkins[5]. It was first recognized in this country by Conn[6], who found it in the reservoir of the Middletown (Connecticut) waterworks. Since then it has been known to cause trouble in a large number of prominent Eastern water supplies.

The colonies in the LaFayette water were just visible to the naked eye, being considerably less than $\frac{1}{100}$ (one one-hundredth) of an inch in diameter, and spheroidal in shape. Each colony is made up of a delicate gelatinous matrix, in the periphery of which are imbedded two hundred or more individual monads, these monads having two flagella each, chromatphores, and, quite important to us in connection with water supplies, many oil globules variously distributed throughout the cell. It is supposed, and with good reason, that these are the direct source of the oily taste and smell in the water. When the colony is intact, in its normal condition in the water, very little if any odor can be detected; but let that water be disturbed in such a way as to rupture or disintegrate the colonies

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[1] Die Infusionsthiere als vollkomna Organismen. Leipzig, 1838.
[2] Zeitschrift für Wissenschaftliche Zoölogie. 1878. Bd. XXX, p. 265.
[3] Organismus der Infusionsthere, III. 1878.
[4] Manual of the Infusoria, I. London, 1881. (W. Saville Kent.)
[5] On Uroglena. G. N. Calkins, in Annual Report Mass. State Board Health, 1891.
[6] Report of Water Commissioners for 1889, Middletown, Ct.

and the odor becomes quite strong. This, of course, is what occurs when the water runs into the service pipes. The change of conditions causes the disruption of the colonies, and so we get the smell and taste in the hydrant water, but almost none in the water examined fresh from the reservoir.

This matter of the cause of such odors and tastes in drinking waters has been the subject of much study by the Massachusetts State Board of Health[1], and I had the privilege of doing some work in that line in 1894, while connected with that Board. Most of the experiments were conducted on this Uroglena because it had such a strong and characteristic odor. Large quantities of water containing an abundance of Uroglena were filtered through cotton, and this cotton was immersed in ether and several other solvents of oil, particularly the volatile ones. Then the ether was allowed to evaporate, leaving an oily residue on the watch glasses which in some cases gave the characteristic odor, somewhat intensified. But in nearly all of the experiments trouble was caused by the ether itself leaving a noticeable residuary odor after evaporation, which was in some instances quite misleading. The Uroglena oil, however, was collected, and did to a certain extent have the sought for odor. Among the other solvents tried were carbon bisulphide and chloroform, with the same difficulty of the residuary odor.

The ordinary method of microscopical analysis (Sedgwick-Rafter) is practically useless in determining the numbers of Uroglena colonies in a given quantity of water, because of the readiness with which the organisms break up. The estimates consequently in such cases would be far too low. In the analysis of the water supply of Lafayette made last October the water was examined without making any attempt to concentrate the organisms. Cubic centimeter after cubic centimeter was examined directly with a small hand lens, and in no case were there more than twenty colonies per 100 cubic centimeters. The average was six per 100 c. c., but this was sufficient to give the offensive odor to the water when drawn from the faucet. As was found in other cities, and as we might expect to find in Lafayette, the water drawn from the housetops in the morning, while giving the odor, showed absolutely no Uroglena colonies.

The question naturally suggests itself, how did the reservoir get planted with this troublesome organism? Of course we can make no definite statement in regard to this, but an examination of the reservoir overflow, which forms a more or less stagnant pond just below the reservoir itself, showed a larger number of these Uroglena colonies per 100 cubic centimeters than the reservoir water, and it

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[1]Odors in Drinking Waters. G. N. Calkins. Mass. State Board of Health, Ann. Report, 1892, p. 355.

would not be very difficult to imagine that birds flying directly from the overflow to the reservoir might carry the organisms there.

To get rid of the trouble in this case was comparatively easy, because the reservoir was small and it was not a difficult matter to entirely change the water in the reservoir by keeping the pumps going full force day and night for a few days. In three weeks from the time my attention was first called to the matter, I was unable to find any Uroglena in the reservoir water, and I have heard no complaints since.

It is not known that the Uroglena, even in very great abundance in the water, causes any disturbance or inconvenience to our bodies. It is most important, however, that the city engineers and waterworks superintendents should know this, in order to so inform the people when they make their complaints. The suffering public under such circumstances are apt to imagine that all sorts of ills are caused directly by this to them unseen pest, and they are too prone to find fault with the water supply. While we can not prophecy when Uroglena may appear in or disappear from a water supply, we can state with much certainty that it is perfectly harmless, and that it does not necessarily indicate a bad condition of the water. The Lafayette water, for the past two years at any rate, has been absolutely free from all dangerous contamination, and the recent appearance there of Uroglena does not mean that the water supply is at all degenerating.

The Engineering Research Laboratory in Its Relation to the Public.

By W. F. M. Goss.

In the present era of the world's progress we hear much of our "material prosperity" and of the "development of our resources." Feeling sure that the earth was made for man, man is anxious to make his possession yield him its best. Nor is he contented with what his own immediate neighborhood can furnish. If there is anything in the ends of the earth, or in the air, or in the sea which is capable of making for his advancement, he rests not until he has secured it. The business of the world, therefore, increases with every hour, and its problems multiply.

In the midst of its hum and hurry, the engineer is a prominent figure. It is his province to study the properties of matter and to make them useful to man in structures and machines. He deals with the mining and reduction of ores, the chemical and physical properties of metals, and all the great variety of processes by which iron and steel are shaped for purposes of construction; with earth-work

dams, with systems of municipal piping, with steam engines and pumping machinery, with locomotives and other railway equipment, with bridges and buildings, with ships and harbor improvements—in fact, with structures and machines of every conceivable type.

The engineer is the servant of the people. His ingenuity and skill are the starting point which leads to the employment of all the artisans who fill our shops and factories; his work makes possible the peace and comfort of household life, the success of social affairs and the perfection of business methods, and it often serves to furnish inspiration for modern thought and to give direction to its tendencies.

The basis of the whole science of engineering, extensive as it is, is to be found in facts which have either been deduced from practical experience or derived from especially conducted experiments. The early engineer could neither lean upon accepted theories nor look to precedent for guidance. It was not what Brindley, and Telford, and Watt, and the two Stephensons *knew*, but what they *did*, that helped to inaugurate our present era of engineering. Since their day, every important structure has served a double purpose: first, that for which it was especially designed, and, secondly, that which regards it as a subject for observation and study. Where such structures have been a complete success, information concerning them has become a matter of record, and the essential facts have been given a place in the annals of good engineering practice; and where structures have failed, the causes have been carefully studied, that the fault might be understood and consequently avoided in future work. Successes, therefore, have inspired imitators, and failures have warned all followers.

But while it is in this manner that a large part of our present fund of engineering data has been brought into existence, and while the process still goes on, it is admitted to have its limitations. The attempt to build a house and at the same time determine the subsequent behavior of certain details entering into its construction, is illogical and expensive. For example, it is poor economy to ascertain the strength of an iron column by finally seeing it fall under the load of a wall. A crack in an arch or a fragment from an exploded boiler may testify to faults in construction, and may even serve as a basis for theories leading to better practice, but the information obtained is dearly paid for in the damage suffered by the collapse of the arch or the explosion of the boiler.

Again, great as are the losses occasioned by failures, they do not equal those which occur through fear of failure. The fear that workmanship may be bad or materials defective leads to lavishness which could not be justified if our information were more definite. It is indeed true that "factors of safety are factors of

ignorance." When it is doubtful just how great a resistance can be withstood by a given bulk of material, we make success certain by building many times stronger than is really necessary. If we could know at the outset the exact value of the stresses involved and the actual strength of the materials to be employed, it would become obvious that such a practice as this could give no additional security, and its result would be wastefulness.

In the domain of machine construction the same general principle applies. The demand is everywhere made for machines that will act with a higher degree of efficiency; that is, do their work with less wear and tear and at a lower running expense. There is no lasting market for inferior goods, and success in competition is to be obtained as the result of merit. Thus it is that designing engineers who give their thought and skill to planning great bridges, buildings and machines are successful in proportion to their ability to simplify and cheapen and at the same time perfect, while all unite upon the general principle that a bridge must not only stand, but it must also involve a minimum of material, and a machine must not only run, but must do its work with the highest degree of efficiency.

It is clear, therefore, that what is needed in engineering work is a more perfect knowledge of the materials and forces involved. This is not a reflection upon the knowledge of the past, but a suggestion that its fund is insufficient for the future. The engineering of the last quarter century has done much to make definite matters which were before but little understood. Facts have been gathered and compared, and from them theories have been deduced. Failures are fewer and the efficiency of structural work, and of machines of every sort, has been increased. But the end is not yet. To-day, more than ever before, the attention of the whole engineering world is directed to methods of improving and saving. Its efforts are put forth in response to the demands of a more exacting clientage, and this clientage is the public. It is evident that everything which contributes to the perfection of engineering methods must benefit the people and must arouse their interest, for it is the people who finally reap the advantages, as well as pay the price. Hence public interest in the work of the engineer is keen and critical, and will always sustain any serious movement which promises to advance true practice. Such a movement presents itself in the establishment of laboratories devoted to engineering research.

When all forms of mechanical construction were crude it was possible to improve by the mere application of experience, but as construction became more refined it was necessary to examine with greater accuracy and to proceed with greater care. The crude stage in engineering is now a thing of the past, and

every day increases the degree of refinement which characterizes the work. The research laboratory stands as a response to these conditions. It is its function to investigate, in a scientific manner, problems which arise in practice or which may be suggested by practical experience. The fields of science and the field of engineering combined make up its proper domain. Its equipment, therefore, embraces the delicate apparatus of the scientist and the ponderous machinery of the engineer, and its lines of investigation may be chemical, metallurgical, structural, pneumatic, hydraulic, or thermodynamic. Its methods eliminate the complicating conditions of service and allow effects to be traced singly to their causes. For example, efforts to determine the power and efficiency of locomotives while in service upon the road extend back through more than three decades, with no general result that is satisfactory. But the difficulties and inaccuracies which appear in the process of road testing entirely disappear when tests are made in the laboratory, for here it is possible to maintain for an indefinite period an unvarying condition of speed and load, and to employ sensitive apparatus in observing the performance of the machine.

There have been many instances where locomotives on the road have left bent rails in the track behind them, but it required the laboratory to demonstrate that under conditions not uncommon in practice, the drive-wheels of a locomotive leave the track at every revolution. This being proved, the matter of the bent rails was easily explained.

Again, it has been assumed for years that the draft produced by the exhaust steam in a locomotive was the result of an action similar to that of a pump; that each puff from the cylinders supplied a ball of steam which filled the stack as a pump piston fills its barrel, and pushed before it a certain volume of the smoke-box gases until it passed out at the top of the stack. Believing this view to be the true one, designers have shaped the details of locomotive draft appliances accordingly, and the value of proposed improvements has been measured by the completeness with which they have satisfied the conditions of the accepted theory. But the processes of the laboratory have disproved this whole assumption. They have shown that the steam does not fill the stack except at its very top, and that the action of the jet is clearly one of induction. In accordance with these results a new theory has been formulated, and although it is but a few months old, the laboratory facts which sustain it are so conclusive that it has already been generally accepted. These illustrations, drawn from a single field of investigation, will serve to show something of the character of the work done by the research laboratory. They might, with equal justice, have been selected from any one of the many different departments into which engineering research may

be divided. But they have served their purpose if they have emphasized the fact that the laboratory process gives results which can not be obtained in any other way, and that these results may be relied upon to guide and direct practice in engineering affairs.

English technical papers admit that the painstaking processes of German laboratories have so well guided German manufacturers that Germany not only competes with England in many lines of manufactured goods, but in some has driven her from her markets. We have a new country, in which large engineering enterprises, both public and private, are always being pushed and are calling for economy in expenditures; and there is a strong national desire for an outlet of manufactured goods through exportation, which can only be secured on merit, in competition with the world. With these facts in mind the conclusion is obvious that there is room and need in this country for research laboratories. All such laboratories are but means to ends. They are not only contributors to the public fund of information, but they infuse into every branch of construction and of operation a spirit of accuracy and a desire for excellence.

Louisville Filtration Experiments. By Geo. W. Benton.

The 1st of August, 1896, completed the routine work of one of the most unique series of experiments the scientific world has had the privilege of witnessing.

The question under investigation was the chemical and bacterial condition of the Ohio River water, as furnished the City of Louisville, Ky., and the relative merits of the several systems of filtration seeking establishment there, and proposing to do away with the mud and its accompanying bacterial impurities, so familiar to the citizens of and visitors in the great cities adjacent to the Ohio, the Missouri and the Mississippi rivers.

The peculiar yellow clay suspended in the Ohio water will not subside even on standing, and ordinary schemes of filtration utterly fail in its treatment, even in times of low water.

In view of the conditions, Mr. Charles Hermany, Chief Engineer, and Mr. Charles R. Long, President, of the Louisville Water Company, decided that the only sure way to treat the question was by means of an experimental plant erected on the ground and operated for a term of months, which should give them definite knowledge of the water in every stage. In accordance with this

plan, Mr. Long issued an invitation to all the large concerns engaged in the filtration of water on an extensive scale to establish experimental plants at the pumping station. The terms of the arrangement were as follows:

Each company entering the competition to establish its own plant and operate it with its own representatives in charge; the Water Company to provide temporary buildings for the housing of these plants, the necessary steam power, and the unfiltered water to be used in the experiments. The entire operation of the plants to be under the supervision and control of a competent staff of engineers and scientific experts in the employ of the Water Company, who were to have access at all times to the several plants, keep accurate records of metre readings, both of filtered and unfiltered water, to take samples at any time and at any stage, to examine the chemicals used as to quality and quantity, and to note the expense of the power required for operating the machinery.

Four companies entered the competitive test, namely: (1) The O. H. Jewell Filter Co., of Chicago, presenting the Jewell Filter; (2) The Cumberland Manufacturing Co., of Boston, presenting the Warren Filter; (3) The Western Filter Co., of St. Louis, presenting two filters, the Western Gravity and the Western Pressure; (4) The John T. Harris Magneto-Electric Purifying Co., of New York, presenting a process based on electrolysis.

These filters are doubtless well known to those interested in water examination, as they are extensively advertised, and time will not be taken to consider the details of their operation.

Work began October 1, 1895, with a laboratory force of three, including Mr. George W. Fuller, Chief Chemist and Bacteriologist, in charge; Mr. R. S. Weston, Chemist, and Mr. C. L. Parmelee, Engineer. This force was gradually increased until, at the close of the period of work, there had been added to those already mentioned Mr. J. W. Ellms, Chemist; Mr. G. A. Johnson, Clerk; Mr. H. C. Stevens and Mr. R. E. Bakenhus, Engineers; Mr. Hibbert Hill, Bacteriologist, and myself. I can not refrain from expressing at this time my high appreciation of the enthusiasm and untiring energy, the skill and scientific value, of the experts named. The volume of work was enormous, and during the month of July, when I had the privilege of ranking as one of the force in the bacterial laboratory, our chemical thermometers frequently ranged (expressed in Fahrenheit degrees) 98 to 100. The excessive heat had no effect upon the work. Every man seemed infested by the work bacillus, and spread contagion throughout the whole plant. During July, not counting specie work, which constantly went on, over fifteen hundred bacterial samples were plated and counted; in many cases, recounted the second time. The chemists were equally busy.

Ethical as well as business reasons prevent the announcement of even approximate results, the complete elaboration of which will appear over Mr. Fuller's name early in 1897, whether in public form or as a private report to the Louisville Water Company I am not informed. In any case, the matter which it will contain concerns not Louisville alone, but the world as well. It is to be hoped that water experts will have access to it. I believe that I am entitled to say, however, that Ohio River water has been successfully filtered in quantity, under the most extreme conditions, during the course of these experiments. It has come from the filters clear and sparkling, on days when the chemists found in the neighborhood of 3,500 parts of solids per million, and when the river showed 12,000 to 25,000 bacteria to the cubic centimeter, I have counted six to ten individual colonies in the filtered water.

The equipment of both chemical and bacterial laboratories was complete and thoroughly up to date. The methods for bacterial work, preparation of media, classification, etc., were mostly taken from unpublished manuscripts. The steam sterilizer was largely replaced by the autoclave, at a pressure of 20 pounds and a registered temperature of 126 degrees Celsius. Color tests were a feature of the chemical work. the method being that of the Massachusetts State Board of Health.

Chemists and bacteriologists can not praise too highly those members of the Louisville Water Company, who, in the face of much criticism, and at such great expense, have not only made possible the solution of the question of their own water supply, but that of the great cities of the Mississippi basin, and at the same time placed in Mr. Fuller's hands the means of enriching our experience in the handling of refractory sources of potable waters for cities.

Indianapolis, December 30, 1896. GEO. W. BENTON.

A "TORNADO" IN RUSH COUNTY, INDIANA, AUGUST 1, 1896. BY W. P. SHANNON.

On the first day of last August there was a destructive storm along the southern line of Rush County. Approximately, we may say, it began near Milroy in Rush County, and ended near Metamora in Franklin County, running from west to east on a line bearing but little to the south. It was not continuous. The most destructive part of its course was shortly after the beginning, on my old home farm. I visited the place two days after the storm. My brother, H. F.

Shannon, who was in the storm, described it as a cannonading from the clouds, and, as the evidence shows, this figure is a good one.

What seemed to be an ordinary rain cloud rose from the north. In a short time the cloud showed that it was bordered behind with a straight line, and the blue sky appeared beneath. It seemed that in a few minutes the cloud would be over and all would be bright again, when suddenly from the rear edge of the cloud in the northwest vapor began to puff downward; in a moment a broad band of buff-colored cloud reached from the main cloud to the ground, not straight down but obliquely to the south, and curving more southward near the ground. This band was a half or a mile wide, the width of the storm as it was approaching; then parallel bands began to float southward from the main band. Then the real nature of the band began to show itself— it seemed that shots were being fired fast and thick in front of the main band from the upper cloud to the ground. Imagine the smoke from a cannon to continue to boil from the ball as it progresses, and you have a picture of one of these shots as it went from the cloud to the ground. The buff color, or the dust-like appearance, may have been due to electricity. The storm ran from west to east along the well defined rear edge of the main cloud.

While the storm was passing, my brother was in a barn near the south doors, which were open. (The roof of the barn slopes to the east and west). While the storm was approaching it gave a rumbling sound, while it was passing it made a hissing sound, and the air was so full of vapor that the house, a few steps from the barn, couldn't be seen. Suddenly there was a dead thud on the west side of the barn, then a deluge of water poured from the hay above, and all who had taken shelter in the barn had to gape for breath. Then he saw passing obliquely before the open door what he took to be the head end of one of the shots. It was like frost particles moving among one another, as bees while swarming. The thud west of the barn was another one of those shots. Those who were in the house had retreated to the cellar, when they were deluged with water. They noted the hissing sound and a glare of lightning over the ground, and had the same difficulty to get their breath. A woodhouse and the porch connecting it with the house were knocked into pieces, and large trees about the house and barn were broken off or uprooted; but no one heard any crashing of timber or buildings, the only noise was the hissing sound.

A hundred acres of corn west and northwest of the barn was laid flat. In a piece of timber, beyond the corn, three-fourths of the trees were knocked down. In another piece of timber, southwest of the barn, nearly all of the trees were down. About forty rods east of the barn is another tract of timber. In a hundred

acres of this more than half the trees were down. A map of the 2,000 acres of land covering the most destructive part of the storm's course, with lines showing the directions in which trees were thrown, should have the lines arranged fan-shaped, running from north to south on the western border of the map, and from west to east on the northern border. These lines may be evidence that the storm was not a tornado.

My brother took me over the ground and showed me the records of the work. They were not so striking as immediately after the storm, but they were still plain. In a piece of bottom land, covered with horse weeds, a large sycamore tree had been turned out of root, and in a circle of fifty feet or more in diameter about the root of this tree the horse weeds were flat, almost beaten into the ground. It looked as if a great ball of water, or something, had struck the ground there and turned the tree out of root. It was no trouble in the patch of horse weeds, or in the corn field, or in the grassy woodland, to pick out where every shot had struck the ground. In every case where a shot struck the ground in front of or at the base of a tree, the tree, if green, was turned out of root, if dead, was broken off even with the ground.

In most cases where the shot struck a tree above the base, the tree was broken off. In one case, while standing at the base of an upturned tree in the center of the spot of flattened grass, we could tell by looking upward and westward, the course of the shot by another tree that had been topped in its path. In another case we were standing in the center of a spot of flattened horse weeds, wondering why the shot didn't hit one or the other of two ash trees on the west side of the spot; soon we observed by limbs broken away that the shot had passed between the two trees. In nearly every case where a tree had been topped, we could find the spot of flattened grass a little distance east or southeast of the base of the tree, the direction depending upon our position in the devastated area. In this way we could, in nearly every case, make out the path of the shot through the air. Near the central part of the devastated area the shots moved from the northwest downward at an angle of 45°. In the eastern part of this area they moved nearly eastward at an angle of 30° with the horizon. In some cases a dead tree was unharmed, while a green tree near by was turned out of root, or had its top cut off. There was evidence that, on the south margin of the devastated area, trees were blown down by the wind; but in the central part they must have been knocked down by globe lightning, or something else, shot from the cloud.

The evidence is that each shot was accompanied by electricity, rarified air, and a deluge of water. The appearance resembling particles of frost flying among one another, as swarming bees, suggests electrified snow. Such a suggestion may lead to experiment. What kind of a storm was this?

Comparative Crushing Strength of Cubes and Prisms of Bedford Limestone. By W. K. Hatt.

[Abstract.]

An examination of the curve representing Baushinger's experiments on the crushing strength of stone cubes as compared with the strength of stone prisms, will show that the law of variation of strength is such that the strength of a prism whose height is 1½, the length of its base will be only 92 per cent. the strength of a cube of equal section. It is a matter of doubt whether such a difference will occur between tests of any given specimens of the variation in height mentioned under the ordinary condition of testing.

Tests of 31 specimens of Bedford Limestone (of rather soft variety) made at Purdue University, show that 17 cubical specimens (4x4x4) were slightly weaker than 14 prisms (4x4x6) of the same material, subjected to the same conditions throughout. Specimens were bedded in plaster of paris. The average angle of failure in shearing was 64.5 degrees.

Some Mounds of Vanderburgh County, Indiana. By A. H. Purdue.

Exactly in the southeast corner of Vanderburgh County, Indiana, is a collection of mounds and earthworks, which, so far as I am aware, have never been fully described,* and which are doubtless among the most interesting of the State. They are locally known as the Angel Mounds, taking their name from the owner of the land on which they occur.

As the ground upon which they are situated is nearly all under cultivation and the mounds are rapidly disappearing, it is desirable that a description of them be placed in permanent form.

The remains are situated upon the alluvial soil of the Ohio River, north of Three Mile Island, and lie between two bayous, one on the south separating Three Mile Island from the main land, and an older one on the north.

When in a perfect state there was probably an inclosure, formed by the bank of the bayou on the south and an irregularly curved wall, presumably a rampart, either end of which was terminated by the embankment. At present there are about 1,400 yards of this wall remaining. As it now stands it is from 5 to 10 feet wide at the base, and from 1 to 2 feet high. At intervals, usually of from 37 to

*An imperfect description of these mounds will be found in the Smithsonian Report, 1881, p. 591.

40 yards, there are semicircular mounds with radii of from 5 to 8 feet, joined to the outer side of the wall. On the supposition that the wall was a rampart, these semicircular projections from it were probably lookouts from which the guards could easily flank the outer face of the wall. It will be seen by reference to the map that there is within the outer wall a similar inner one, which terminates in Mound No. 2. There is evidence, though very slight, that this wall formerly extended from Mound No. 2 southward. It is possible that it marks the border of the original inclosure which was afterward extended to the outer wall.

The area included between the outer wall and the embankment north of the present bayou is a little more than 95 acres.

The most striking object among the collection is the large mound within the inclosure. Its longest diameter is 500 feet. Its width varies from 175 feet to 225 feet. With reference to altitude it is divided into three parts. The southern part, which is 160 feet long and which has been under cultivation for years, varies in height from 6 to 9 feet. The east border of this part is somewhat obscured, from cultivation and erosion, but the south and west borders are distinct. The second part of the mound rises about 17 feet above the first part, and is 26 feet above the base. The top is flat and is 240 feet long by 112 feet wide, and has been utilized until recently for an apple orchard. The third part is a dome 13 feet high and stands on the southeast corner of the second part. The base of this dome is about 48 feet in diameter, and the highest point is 39 feet above the ground on which the mound rests. If the trees along the Ohio River were removed, the top of this dome would afford a commanding view for several miles up and down the river.

I shall not even venture a conjecture as to the purpose of this remarkable mound.

Besides this, there are six other mounds within the inclosure, denoted by Arabic numerals. These mounds are all circular at the base and have rounded tops, except No. 3, which is a truncated cone. It has a diameter of 160 feet and is 10 feet high. Trees of walnut, oak and maple are growing upon it. The largest tree is an oak, which is 2½ feet in diameter. This mound has for a long time been used by the people of the vicinity as a burying place. Mound No. 1 is 115 feet in diameter and 12 feet high; No. 2, 90 feet in diameter and 6 feet high; No. 4, 100 feet in diameter and 5 feet high; No. 5, 60 feet in diameter and 4 feet high; No. 6 is a small indistinct mound.

All of the small mounds, except No. 3, are being cultivated.

In Mound No. 5, Mr. Charles F. Artes, of Evansville, reports having found 13 human skulls, 12 of which formed the circumference of a circle, the thirteenth

being in the center. All were well protected by slabs of shale. No human remains are reported from any of the other mounds.

In the southeast part of the inclosure the plow frequently brings to the surface bones of birds, small and large mammals, and human beings. This is for that reason designated on the map "Burying Ground."

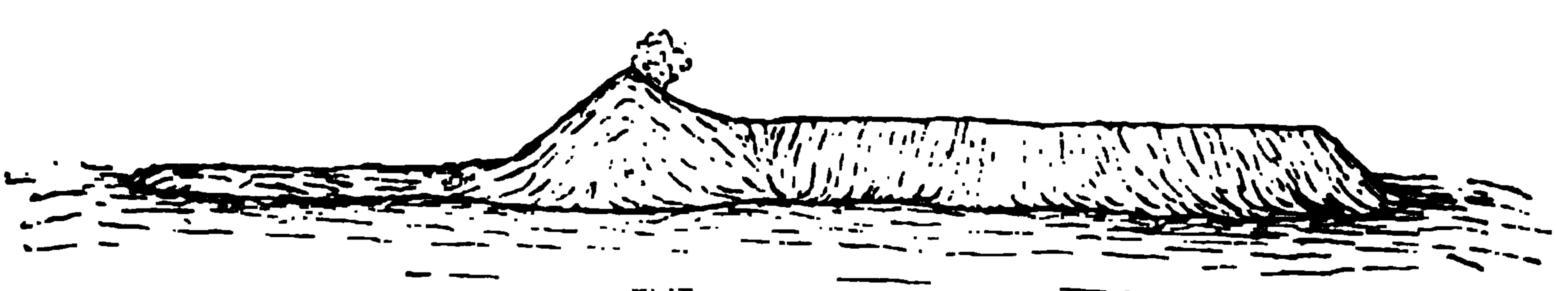
Pieces of pottery, such as is now made by the western Indians, are common within the inclosure.

On the north side of the old bayou, beyond the area shown in the map, is an old excavation, from which a portion of the earth in the mounds was doubtless obtained. In this excavation are stumps of oak trees, two feet or more in diameter.

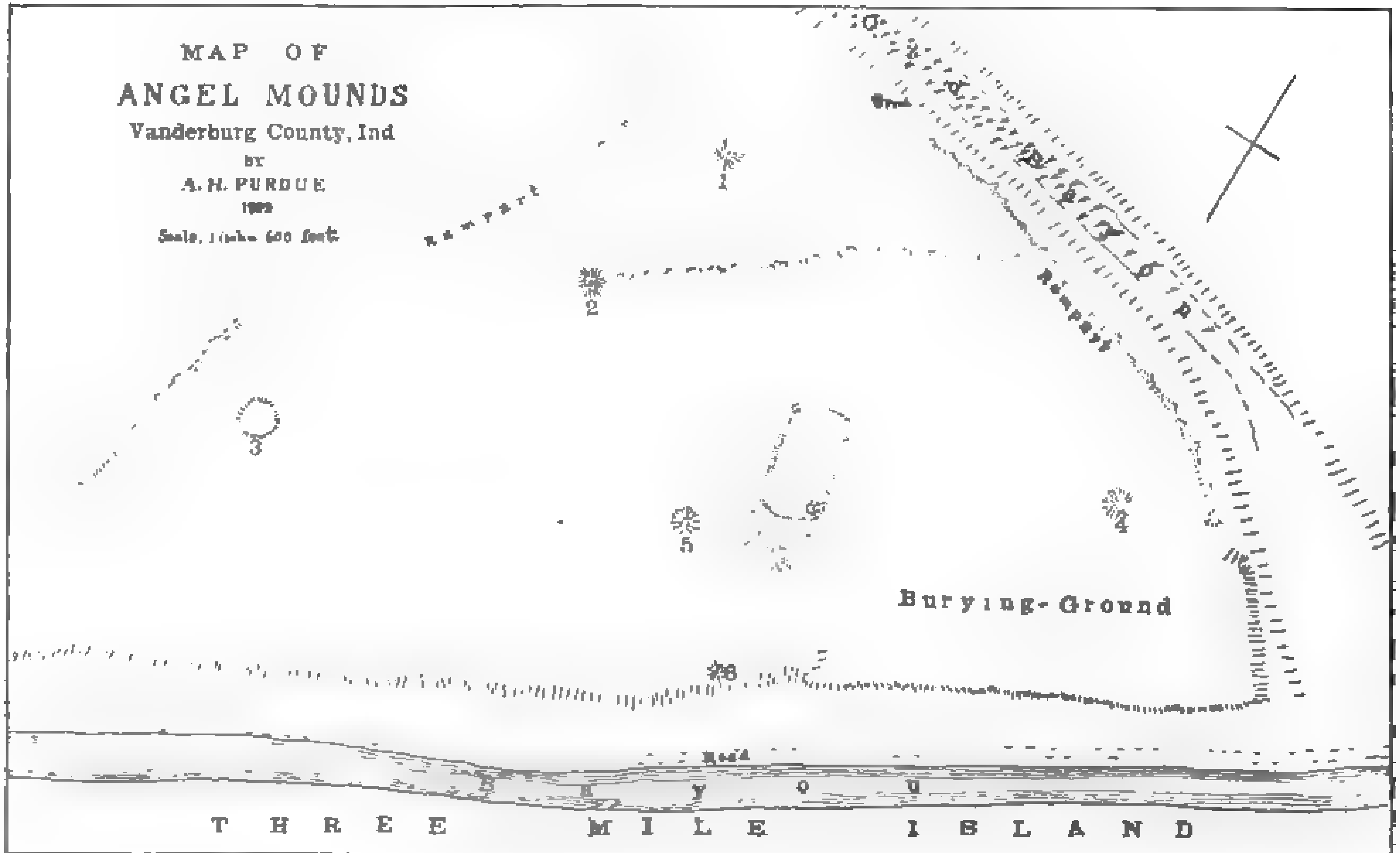
A striking feature of these mounds is their perfect state of preservation. True, the rampart, if it were such, has been greatly reduced in height; but this is probably due to the fact that most of it overflows during the Ohio floods. The east end of the natural embankment north of the bayou and south of the Burying Ground was improved, and, with the exception of a few small washes, now stands as it was left by the aboriginal men who did the work. The large central mound, except where cultivated, is apparently in a perfect state of preservation. The apparent recency of the work certainly indicates that it is none other than that of the American Indians.

Why these mounds were located here on this alluvial soil, most of which overflows, and which is productive of malaria, while the highlands are only a mile north, and three miles to the northeast, at the town of Newburgh, is one of the most commanding views along the entire course of the Ohio River, is a question.

About a mile northeast of the large mound is a single conical mound, 150 feet in diameter and 25 feet high. There are several small mounds along the alluvial deposits of the Ohio in Warrick County.



Angel Mound (1894)


MAP OF
ANGEL MOUNDS
Vanderburg County, Ind
BY
A. H. PURDUE
Rampart
Rampart
Burying-Ground
Road
Bayou
THREE MILE ISLAND
1
2
3
4
5
6

THE LAKE MICHIGAN AND MISSISSIPPI VALLEY WATER SHED. BY T. H. BALL.

Commencing near the headwaters of the Des Plaines River in Wisconsin, but a few miles from the shore of Lake Michigan, then passing southward, winding slightly, passing within eight miles of Lake Michigan, and then, just west of the city of Chicago, passing the south arm of the peculiar Chicago River, still going southward, this line passes west of Blue Island, eight miles west of the Indiana State line. It then passes southwest around the headwaters of Rock Creek, and then, southeastward, around Thorn Creek, which is its most southern point in Illinois, and is near Eagle Lake, two miles west of the Indiana line and directly west of the Lake County village of Brunswick and twenty three miles south of the State line monument on the shore of Lake Michigan. This line then passes northward and enters Indiana and Lake County in section 36, township 35, range 10 west of the second principal meridian. It then bears southeastwardly around the headwaters of West Creek, to a high, wooded ridge about a quarter of a mile north of Red Cedar Lake, and then passes along a low, curving ridge on which was once a wagon road, the most beautiful and best marked portion of the line in Lake County. It passes eastward three miles over a timbered table-land, and running south of the center of Crown Point about two miles, it passes across section 17, on which was laid an "Indian float," and the south part of section 16, township 34, range 8 west, and then south on the east side of the old Stoney Creek, and east across sections 35 and 36, in township 34, range 8, and into section 31, range 7 west, where is now the village of Le Roy, and where it turns northward, having reached its extreme southern limit in Indiana. Here it winds around the head of the south branch of Deep River, passing between that and Eagle Creek, and bearing eastward, south of Deer Creek, it leaves Lake County almost due east of the center of Crown Point, distant from that town seven miles and a mile and a half, nearly, south of its point of entrance into the county. It then passes north of a little lake, and then east, and then in a northeasterly direction across Porter County, running barely south of Valparaiso and north into Liberty Township in township 36, range 6, then east across Jackson Township into Laporte County. Passing the city of Laporte and running eastward near the line of the Lake Shore Railroad, distant a few miles only from the north line of Indiana, it turns again southward till it comes into Portage Township in St. Joseph County, a little west of South Bend. And here on this noted portage between the St. Joseph and Kankakee Rivers, this notice of this watershed line will close.

It may prove a matter of interest to some, in another generation, to have this line traced with even this much definiteness, although, of course, it has not been given with the entire accuracy of a surveyor's field notes; for the drying up of water courses and the drainage by means of large ditches have already almost consigned to oblivion the names and the winding beds of some of the small treams that were well known to the Illinois and Indiana pioneers.

Some Notice of Streams, Springs, Wells and Sand Ridges in Lake County, Indiana. By T. H. Ball.

Some of the natural features of Lake County, Indiana, are rather peculiar, and are quite surely of interest to students of physical geography.

Bounded on the north by Lake Michigan, on the west by Illinois, on the south by the Kankakee River, if the waters of Lake Michigan ever passed southward into the Mississippi and the Mexican Gulf, as some suppose, the outflow was quite surely over a part of what is now Lake County.

Of the two most southern points of the Lake Michigan basin, as stated in a former paper, one is in Lake County, eighteen miles south of Lake Michigan, and the other is distant about fifteen miles, almost exactly west, not far from the Illinois line.

North of the water shed the beds of the streams have an easterly and westerly direction mainly, or northwesterly and northeasterly, while south of this line the streams flow mainly southward. The Calumet, the largest northern stream, is quite peculiar in this respect, that it flows across the county nearly twice, one stream known as the Little, the other as the Grand Calumet. The windings of the bed of Deep River, the second in size, are quite remarkable, and this stream, for some two miles of its course, flows due north.

While not a region of brooks, there are, nevertheless, in this county, some interesting and remarkable springs, about twenty in number, that are quite well known. Three of these are near Crown Point, and in the Deep River Valley. One has excellent, healthful, mineral properties, and one will furnish water sufficient, so its owner believed, to supply the wants of a thousand head of cattle each day. A fourth of these springs is near Creston, in the Cedar Creek Valley, affording a large amount of water, and covering several square yards of surface. A fifth one, furnishing quite a flow of water, is on the west side of Red Cedar Lake, north of Paisley, at the base of the low bluff. The sixth is on the east side

of the lake, south of the Sigler hotel, some rods out from the bluff, and once covered with the lake water, and the seventh is still covered by the lake water, in the northeast part of the lake, its existence ascertained by bathers, or divers, on account of the change in temperature of the water. Others like it doubtless feed the lake. The eighth to be mentioned here is in the east part of the town of Lowell, in the Cedar Creek Valley, the feeder of a beautiful little fish pond. The ninth, and last, to be specially mentioned, and surely not the least, was known in the early settlement of the county as the Mound Spring, or Springs. These springs, forming quite a stream called Spring Run, are in the prairie, two miles east of the Lowell mill pond, and a mile east of Pleasant Grove. From these springs water was hauled in barrels for three or four years to supply many families of early settlers.

Other fine springs are in Cedar Creek and Eagle Creek townships and along the West Creek Valley, nearly all being lowland springs and furnishing excellent water.

At LeRoy, near the water-shed, there is a well called artesian, sixty-two feet in depth, which is an artificial spring. The water is excellent. There is another like it a mile east of Crown Point in the Deep River Valley, near the river bed, eighty-five feet in depth.

At Hammond, in the Grand Calumet lowland, are three true artesian wells eighteen hundred feet in depth. An effort was made to obtain one on the public square at Crown Point, but after going through 16 feet of earth and clay, 100 of quicksand, 25 of blue clay, 112 of slate and shale, 667 of blue limestone streaked with pure white sand rock, brown sand rock and fine gravel of different colors, and into so-called Trenton rock, in all 3,100 feet, the effort was abandoned. No rising water found.

The sand layers and ridges of the county form an interesting study. The shore of Lake Michigan is all sand, and this sand, generally in ridges, some massive, some low, running about parallel with the shore line, with marshes and swales intervening and some swamps extend to the Little Calumet, with an average width of seven miles. Some of this sand is quite white, some yellowish. South of the Calumet a ridge of sand extends across the county passing out into Illinois for several miles at Lansing, and leaving the county on the east near Hobart. This ridge varies in width, being twenty rods and then less and then more.

The crest is in some places thirty or more feet high. Its direction is nearly east and west. South of it, on the west side of the county, is yet another ridge with a base about as broad and a crest as high, commencing at Dyer on the State

line fifteen miles south of the Illinois and Indiana corner-stone, and passing eastward five miles and three-quarters, then turning northward, taking in the town of Griffith and becoming much broader, it bears northeast and connects with the other ridge near Ross, half way across the county. This ridge seems to have been once washed by Lake Michigan's "proud waves." South of these main ridges and large sand barriers are four special sand banks or small ridges that are worth inspection. One is three miles west of the north end of Red Cedar Lake, a large bank on the West Creek Bluff out of which a few years ago a number of human skeletons were taken. The second is on the northeast shore of that lake, where, also, human skeletons, some twenty in number, were taken out in 1880, and where is now a known, undisturbed Indian burial ground. The third is one mile and a half west of Crown Point, near one of the head branches of Deep River. It is known as the Beaver Dam and is near a large marsh. The fourth is three miles and a half east of Crown Point, near one branch of Deep River. In the north part of Crown Point sand comes within a few feet of the surface, but some prairie soil now lies over it.

The immense bed of sand over the Kankakee marsh region, some five miles in width, is covered by several feet of muck. Unlike the deep white and yellowish sand of Lake Michigan, this marsh sand makes excellent roadbeds, five, north and south, marsh roads having been made with it.

No time now remains for noticing what these few facts indicate in regard to the physical conditions here somewhere back in the mighty past.

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Account of a Morainal Stone Quarry of Upper Silurian Limestone near Richmond.

That bowlders, or rock fragments in some form are to be found in the track of a glacier, is one of the most familiar of phenomena. From Maine to Minnesota, and beyond, these fragments are in a direction southerly, with greater or less deviation, from the rock masses to which they previously belonged. Lines of boulders, pebbles, sand and rock-paste are strung along or spread in the course of the ice sheet; granite from granite quarries, gneiss from gneiss beds, quartz from quartz veins, conglomerate from conglomerates, copper from copper deposits, and so on from wherever they were formed in place.

But that an acre, more or less, of stratified rock should be grasped, *en masse* in the great ice palm and dragged or shoved for miles is not so common.

Professor Orton, in the Geological Report of Ohio, Vol. III, page 385, mentions a mass of Clinton Limestone sixteen feet thick and covering three-quarters of an acre, quite below its geological horizon and resting on glacial clays and gravels which separate it from the blue limestone of the Cincinnati rock beneath.

The subject of this paper is a mass of upper silurian rock, Niagara limestone, or more likely, Niagara and Clinton. It is clearly a drift deposit and was originally the greater part of an acre in extent. It is difficult to say just what is its area as it extends back from the hill-slope, where it is exposed, under a heavy deposit of later, modified drift. The Evansville & Richmond Railroad, which was never finished further than the road bed, cut through it a few years since to its full depth, or very nearly. Portions of the border of this rock moraine had been exposed for time unknown by erosion. A mixture of clay, sand and a variety of small boulders separates this deposit from the Hudson River rock of the Lower Silurian.

Fig. 1 gives a view for near 70 yards east and west. It has been five years since the rocks were cut through, and as a consequence the superposed loose material has drifted over the ledges and into the crevices, partially obscuring the promiscuous jumble of the separate masses. Still it can be seen that the coarse chunks of various sizes and forms are jammed together at all angles.

Fig. 2 represents an instance of a large block glaciated on the under side. The use of a glass will aid in discerning the well-marked striæ. One or more observers who have examined the deposit are of the opinion that the rock was glaciated from above while in place, and subsequently inverted, but the repeated occurrence of such under-polishing and the finding of it nowhere but at the bottom, would seem to indicate that it was caused by sliding over the surface below. Furthermore, some of the blocks, while being shoved along, appear to have tilted upward in front, and as a result were rounded off at the heel. Much of the rock is thick-bedded and very compact. Other portions are softer, disintegrate very easily, are stained brown by iron oxide, and are composed mainly of crinoid fragments. The harder rock contains various species of corals and brachiopods, and occasionally the trilobites *Calymene niagarensis* and *Illænus daytonensis*.

Large bowlders of this limestone are found for a mile and more south and southwest from the main moraine. All must have been removed from a point eight, ten or twelve miles north. The fine exposure of striated bed-rock at Thistlethwaite's pond, two miles to the north, has the striæ pointing south 26° west, which is very nearly in line with this morainal deposit.

Fig. 1. North Side of Cut—East and West. Extent near 70 yards. Shows how the rock masses tip at all angles. G. The ledge that is polished on under side, as in Fig. 2.

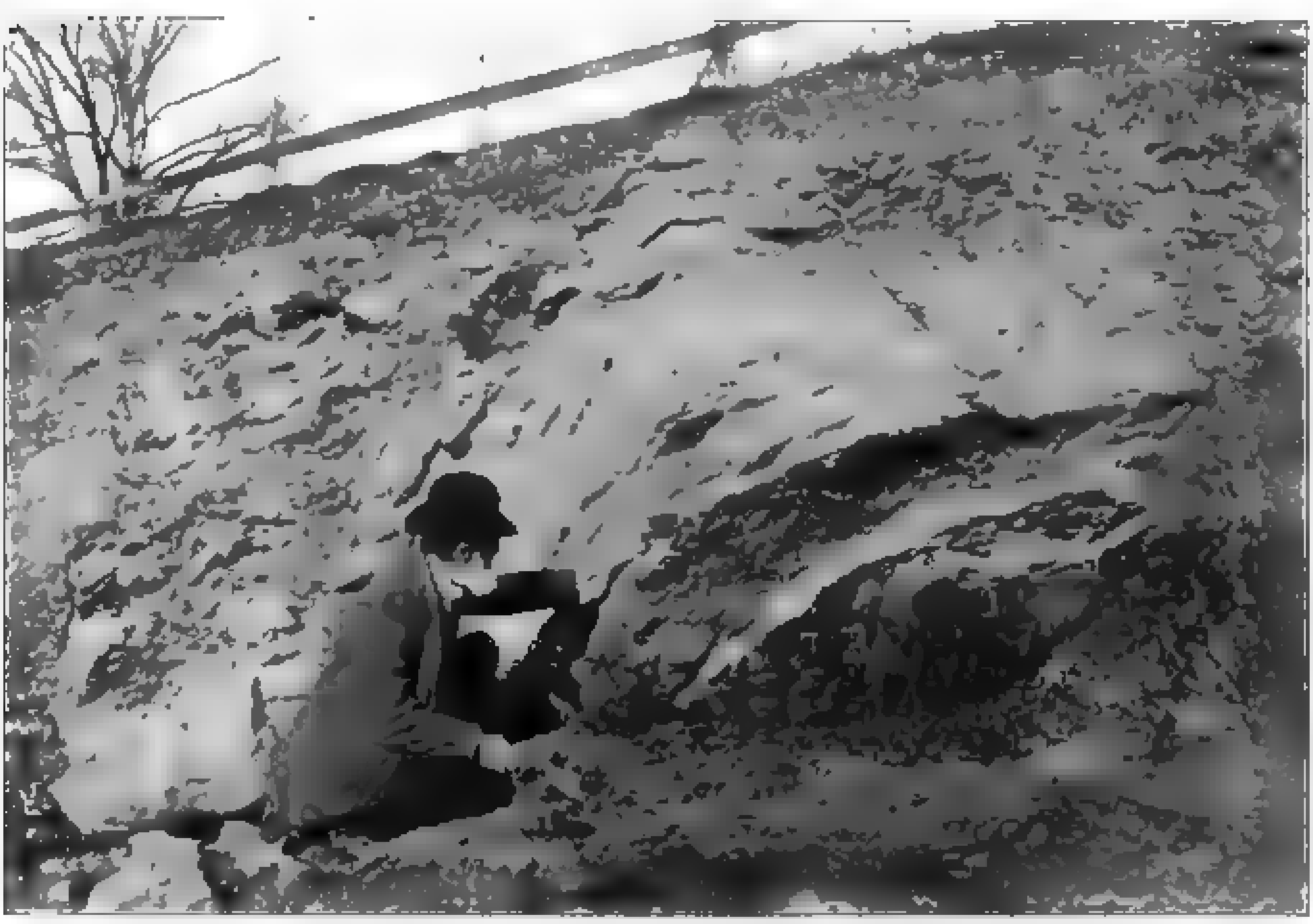

Fig. 2. Nearer view of a mass, marked M in Fig. 1, showing glaciated surface on under side—W. W to E, six feet.

Fig. [illegible] R. R. fill from material blasted out of cut

Fig. 4. West end of moraine as shown by erosion in creek bank below point W in Fig. 1. M, M, M, masses buried in talus. P, pit from which rock has been quarried.

Formulas for Shaft Friction. By J. J. Flather.

Among the various methods employed for the long distance transmission of power shafting has been used to a limited extent.

In many of the earlier applications the motion was one of translation. Thus in the transmission of power from the large overshot wheel at Laxey, on the Isle of Man, trussed rods are used to transmit about 150 h. p. several hundred feet; the rods are continuously connected and are supported on wheel carriers running on iron ways.

This method was adopted, on a very large scale, in the mines of Devonshire for the transmission of power from large overshot water wheels to pumps fixed in the shaft of the mine at a considerable distance higher up the valley.

In one case the water wheel was 52 feet diameter, 12 feet breast, and its ordinary working speed was 5 revolutions per minute. The length of stroke given by the crank to the horizontal or "flat" rods was 8 feet; the rods were 3½-inch round iron, and were carried on cast-iron pulleys.

At Devon Great Consols, near Tavistock, there are altogether very nearly three miles of 3-inch wrought-iron rods, carried on bobs, pulleys and stands, whereby power for pumping and winding is conveyed along the surface to different parts of these extensive mines from 11 large water wheels ranging up to 50 feet in diameter.

In the transmission of power by rotating shafting supported in bearings throughout its length, the friction of the journals is a very important consideration, and effectually debars its use for long-distance transmission.

This can be seen in the following formulæ, which show the relation between the horse-power required to overcome the friction of the shaft due to its weight and velocity, and the horse-power transmitted by the shaft for a given diameter and length corresponding to an angular distortion of $\frac{1}{10}$ degree per foot of length.

If the contact between shaft and its bearing be a line contact only, the initial load which produces friction will be P; on the other hand, if the shaft exactly fits the bearing the friction load will be $\frac{\pi}{2}$ P; midway between these lies a value, P×1.28, or $\frac{4}{\pi}$ P, which will be here assumed as closely approaching conditions of actual practice when the journal is well worn to its bearing.

Under these conditions the friction horse-power will be:

$$H.P_{0}. = \frac{F\,v}{33000} = \frac{4}{\pi}\,\varphi\,\frac{W \times v}{33000}. \qquad (1)$$

In which F = load due to friction;

v = velocity of surface of shaft;

ϕ = coefficient of friction for factory shafting;

W = weight of shaft.

While ϕ varies from 0.03 to 0.08 under different conditions, we have assumed it to equal 0.06 for ordinary factory shafting, with more or less imperfect lubrication and alignment.

If there are no pulleys on the shaft, W will equal

$\frac{\pi}{4} d^2 L \times 3.36$ pounds, where

L = length of shaft in feet, and

d = diameter of shaft in inches.

The horse-power exerted to overcome friction will then be:

$$H.P_0. = \frac{F v}{33000} = \frac{4}{\pi} \phi \times \frac{\pi d^2 L \times 3.36 v}{4 \quad 33000} = 0.000006 d^2 L v. \qquad (2)$$

The horse-power transmitted by the shaft will be:

$$H.P. = \frac{\pi}{16} \frac{d^3 f \times 2 \pi N}{12 \times 33000}. \qquad (3)$$

If we assume the angle of torsion not to exceed $\frac{1}{10}$ degree per foot length of shaft, there is obtained

$$\theta^\circ = \frac{360}{2\pi} \times f \frac{L \times 12}{G r} = \frac{360 f}{\pi G} \times \frac{12 L}{d}; \qquad (4)$$

hence:

$$f = \frac{0.10 L \times \pi G d}{360 \times 12 L} = 800 d$$

when G = 11,000,000; that is, when the modulus of torsion = $\frac{2}{5}$ modulus of elasticity.

Substituting this value of f in (3), and noting that $v = \frac{\pi d N}{12}$, we have:

$$H.P. = 0.0095 d^3 v. \qquad (5)$$

From equations (2) and (5) there is obtained

$$\frac{H.P_0.}{H.P.} = \frac{0.000006 d^2 L v}{0.0095 d^3 v};$$

(6)

that is, $H.P_0. = 0.00063 \, H.P. \frac{L}{d} = \frac{L}{d} \times \frac{H.P.}{1600}$ very closely.

We see from this that the horse-power required to overcome the friction of a one-inch shaft 1600 feet long is equal to the total allowable transmitting capacity of the shaft under ordinary working conditions.

The following table, calculated from this formula, gives the limits in which the power transmitted by a shaft would be absorbed by the friction of the bearings under the above conditions:

Diameter of Shaft in Inches.	Length in Feet When Total Power is Absorbed.	Length When η = 50 per cent.	Length When η = 75 per cent.
1	1600	800	400
2	3200	1600	800
3	4800	2400	1200
4	6400	3200	1600
5	8000	4000	2000

In the ordinary transmission of power by shafting we find the shaft loaded with pulleys and the power taken off by varying amounts throughout its entire length. It is unusual, except in short lengths, to receive the power at one end and transmit it at the other. Moreover, in long shafting the head, or receiving shaft, is usually situated midway between the ends, and the power distributed more or less uniformly from this headshaft to either end; therefore, in estimating the power absorbed by friction in ordinary mill or factory shafting loaded with pulleys, the previous formulæ do not apply, as these relate only to those cases where power is taken off at the end of the shaft.

The conditions of practice, as we find them in actual transmissions are so various, that it is difficult to lay down any general rule by which the power absorbed by friction may be determined. The number and weight of pulleys and couplings, the intensity and direction of belt-pull, the condition of bearings and their lubrication; these all affect the amount of work lost in friction.

For the ordinary factory shafting, from which power is taken fairly uniformly throughout its length and distributed horizontally to counter or auxiliary shafts situated on one or both sides of the main shaft, there will be three general cases to be considered, and each of these will be modified, depending upon the direction of the belt to and from the main shaft.

The friction will evidently be proportional to the weight of the shaft and the unbalanced belt-pull acting on the shaft.

The weight of pulleys, belts, clutches and couplings carried by the line shaft will vary from about one and one-half to three times the weight of shaft, so that the total weight on the bearings will vary from two and one-half to four times the weight of shaft; for head and jack shafts the total weight will probably vary from three to five times the weight of shaft.

In addition to this weight there is the unbalanced belt-pull which increases the load on the bearings. Although the tension on the tight side of the belt may not ordinarily exceed about twice the tension in the slack side necessary for adhesion, yet it is probable that belts are frequently run with a ratio of tension equal to one to three, and occasionally one to four. On the other hand, it is a very common thing for belts, especially short ones, to be laced so taut that the initial tension is greatly in excess of that required for adhesion, in which case the sum of the tensions approaches twice that in the tight side of the belt.

With ordinary shop-worn belting it will be safe to assume that the tension T_2 on the slack side of the belts is one-half the tension T_1 on the tight or driving side, that is $T_2 = \frac{T_1}{2}$, hence, since $T_1 - T_2 = P$, the driving force, we have

$$H.\ P. = \frac{T_1}{2} \times \frac{V}{33000}. \qquad (7)$$

Under the conditions which obtain in machine shops the diameter of a shaft to safely transmit a given horse-power without undue deflection may be obtained from the formula

$$d = \sqrt[3]{\frac{H.\ P.}{N} \times 100}. \qquad (8)$$

Combining (7) and (8) we have

$$H.\ P. = \frac{T_1}{2} \times \frac{V}{33000} = \frac{d^3 N}{100}, \qquad (9)$$

$$\text{and } T_1 = \frac{660\ d^3\ N}{V}.$$

Therefore the sum of the tensions on the entire length of shaft

$$= \Sigma\,(T_1 + T_2) = \frac{3}{2}\, d^3 N \times \frac{660}{V}, \qquad (10)$$

$$\text{or } B_1 = \frac{1000}{V}\, d^3 N \text{ very nearly.}$$

Hence the belt-pull per foot of length of shaft $= 1000 \frac{d^3 N}{L\ V}$. The force of friction, F, acting at the circumference of shaft, is $\frac{4}{\pi} \phi W$, as before, but in this case W equals the weight of shaft, W_s, and its furniture, as well as the unbalanced belt-pull.

The belt tension may act in any direction perpendicular to the axis of the shaft, and the intensity of pull in any given direction will vary from 0 to the maximum to total tension. Besides these tensions there will be an additional pull due to the tensions in the belt from fly-wheel to main line shaft.

Let B_1 = belt-pull due to total tensions acting at an angle, β, with the horizontal;

B^1 = belt-pull due to tensions in main belt acting at an angle, α, with the horizontal;

V^1 = linear velocity of main belt from fly-wheel;

V = average linear velocity of cross belts;

$r = \frac{V^1}{V}$ = ratio of velocity of main belt to average velocity of cross belts,

then the horizontal pull $= B^1 \cos\alpha + B_1 \cos\beta$ (11)

and the vertical pull $= B^1 \sin\alpha \pm B_1 \sin\beta$ (12)

But $B^1 = \frac{B_1}{r} = 1000 \frac{d^3 N}{V r}$; (13)

therefore, the horizontal pull $= B_1 \left(\frac{\cos\alpha}{r} + \cos\beta\right) = x$;

and the vertical pull $= B^1 \left(\frac{\sin\alpha}{r} \pm \sin\beta\right) = y$;

If $\alpha = 0$ and $\beta = 0$,

then $x = B_1 \left(\frac{1}{r} \pm 1\right)$

and $y = 0$.

The most usual case, when the power is not taken off equally on either side, will be that in which main belt makes an angle with the horizontal, and the cross belts are themselves horizontal, that is:

$$x = B_1 \left(\frac{\cos\alpha}{r} \pm 1\right)$$

$$y = \frac{B_1}{r} \sin\alpha$$

When the horizontal cross-belts are distributed equally on either side of the shaft the only load we need consider will be that due to the main belt, in which case

$$x = \frac{B_1 \cos\alpha}{r}, \text{ and}$$

$$y = \frac{B_1 \sin\alpha}{r}.$$

If the machines be driven from below, the pull of the belts, instead of adding to the load on the bearings, will cause this load to be decreased; but as this method is not usual we shall not consider it here.

Combining the load on the shaft due to the belt pull with that due to its weight, the resultant load will be

$$\sqrt{x^2 + (W_s + y)^2}, \qquad (14)$$

hence the friction load will be

$$F = \frac{4}{\pi} \varphi \sqrt{x^2 + (y + W_s)^2},$$

If $W_s = 3\left(\frac{\pi}{4} d^2 \times 3.36\ L\right)$ we have

$$F = \frac{4}{\pi} \varphi \sqrt{x^2 + [y + 3(\tfrac{\pi}{4} d^2 \times 3.36\ L)]^2} \qquad (15)$$

Taking a specific case in which the cross belts are assumed to drive horizontally on each side of the line shaft, and the main belt to make an angle of 30° with the horizontal, we have

$$F = \frac{4}{\pi} \varphi \sqrt{\left(\frac{B_1 \cos \alpha}{r}\right)^2 + \left[\frac{B_1 \sin \alpha}{r} + (7.9 d^2\ L)\right]^2}$$

The velocity of intermediate belting is so variable that any assumption of speed must be regarded as applying to a particular case or representative of a certain type of factory, and can not be taken as general. In many machine shops the average speed of intermediate belts is not more than 500 feet per minute; in others the average speed is more than twice as great, and in wood-working shops it is still greater.

For our present purpose we shall assume an average speed of 660 feet per minute for belts running from the main shaft to a secondary or countershaft, and four times this speed for the velocity of belt from engine to main shaft, that is $\frac{V'}{V} = r = 4$.

Substituting these values in (13) we have

$$B_1 = \frac{1}{4} \times \frac{1000\ d^3\ N}{660} = \frac{1}{4}(\tfrac{3}{2}\ d^3\ N)$$

$$\text{therefore } F = \frac{4}{\pi} \varphi \sqrt{[\tfrac{1}{4}(\tfrac{3}{2} d^3 N \cos x)]^2 + [\tfrac{1}{4}(\tfrac{3}{2} d^3 N \sin x) + 7.9 d^2 L]^2}$$

$$= \sqrt{[0.025\ d^3\ N]^2 + [0.014\ d^3\ N + 0.6\ d^2\ L]^2} \qquad (16)$$

From the formula for the power absorbed by friction we have

$$F v = H.P._{f} = \frac{F \pi d N}{33000 \times 12}, \text{ or } H.P._{f} = 0.0_{5}8\ d\ NF, \qquad (17)$$

hence the ratio of power absorbed by friction to the horse-power which the shaft is capable of safely transmitting will be

$$\frac{H.P._{f}}{H.P.} = \frac{0.0_{5}8\ d\ N\ F}{0.01\ d^3\ N} = \frac{0.08\ F}{d^2} \text{ per cent.}$$

From this expression the following table has been computed for a 3-inch shaft running at 100 and 250 revolutions per minute:

Diameter of shaft in inches.	Revolutions per minute.	Percentage of loss when length in feet.				
		100	200	400	800	1600
3	100	5.1	9.9	19.6	38.7	77
3	250	5.8	10.6	20	39	77½

It is worthy of remark that in long lines of shafting the influence of belt pull on the bearings is very slight compared to the weight of shaft and pulleys, so that the loss in friction is but little more than that due to weight alone.

With better alignment and better lubrication the loss will be less than that here given; in long continuous lines of shafting the bearings are always more or less out of line, and for this reason the loss will be less if short lengths be employed.

Orthogonal Surfaces. By A. S. Hathaway.

It is well known that a given system of surfaces $f(x, y, z) = c$ has in general no pair of orthogonal conjugate systems, *i. e.*, such that the surfaces of the three systems through any point are mutually orthogonal at that point. It has been shown by Cayley [Salmon's Three Dimensions, p. 447] that $f(x, y, z)$ must satisfy a differential equation of third order if it possess a pair of orthogonal conjugates. In the course of some recent investigations on fluid motion I was led to observe that a given system of surfaces might have two pairs of orthogonal conjugates, in which case it would have an infinite number of such pairs. In order that such may be the case $f(x, y, z)$ must satisfy a differential equation of second order which is a particular integral of Cayley's equation of third order. This differential equation is, in Cayley's notation,

$$[(a, b, c, f, g, h)(L, M, N)^2 - (a+b+c)(L^2+M^2+N^2)]^2$$
$$= 4(L^2+M^2+N^2)(A, B, C, F, G, H)(L, M, N)^2$$

where L, M, N, a, b, c, f, g, h, are the first and second differential coefficients of $f(x, y, z)$, and A, B, C, *etc.*, are the minors of a, b, c, *etc.*, in the matrix

$$\begin{vmatrix} a & h & g \\ h & b & f \\ g & f & c \end{vmatrix}$$

A very general solution of this equation comes from $a = b = c$, $f = g = h = o$, which are the differential equations of the series of spheres that pass through a given fixed circle, including, as particular cases, concentric spheres, planes intersecting in a fixed line, and parallel planes.

It may be shown that the above equation factors into four factors of the form $\sqrt{b^1 - c^1}\, L^1 \pm \sqrt{c^1 - a^1}\, M^1 \pm \sqrt{a^1 - b^1}\, N^1$ where a^1, b^1, c^1, are the roots of the cubic found by replacing a, b, c in the above matrix by $a - x$, $b - x$, $c - x$. The differential equation may also, by the usual reciprocal transformation $X = L$, $Y = M$, $Z = N$, $U + u = L\,x + M\,y + N\,z$, be reduced to a simpler form.

The preceding differential equation and the resulting theory of orthogonal surfaces were obtained by quaternion analysis. Briefly, if λ, $\lambda\sigma$, are two perpendiculars to the surface normal σ, that are also surface normals, then we have,

$$(1)\ S\lambda\sigma = o; \quad (2)\ S\lambda\nabla\lambda = o; \quad (3)\ S\lambda\sigma\nabla\lambda\sigma = o.$$

We may replace (3) by

$$(3^1)\ S\lambda\sigma\nabla_1\lambda\sigma_1 = o, \text{ or } S\lambda\phi V\sigma\lambda = o, \text{ where } \phi\lambda = \tfrac{1}{2}\,(\nabla_1 S\lambda\sigma_1 + \sigma_1 S\lambda\nabla_1).$$

Thus ϕ is the self conjugate linear vector function, whose matrix is given above. From (1) and (3^1) we find

$$V\lambda\, V\sigma\phi\, V\sigma\gamma = o$$

This determines λ as one (and $\lambda\sigma$ as the other) of the two latent directions of the plane self-conjugate vector function $V\sigma\phi V\sigma\lambda$. There is therefore in general but one pair of normals that may satisfy the conditions of which (2) becomes a condition upon σ, or the differential equation satisfied by $f(x, y, z)$ in order that it may possess a pair of orthogonal conjugates. If, however, the above plane vector function have equal latent roots, then its latent directions become indeterminate. This means that (1) becomes a factor of (3^1) so that the only equations to be satisfied are (1), (2). These may be satisfied without other condition upon σ than the above equality of latent roots which is the differential equation that we have given at the beginning of the paper.

Note. Since presenting the above I have noticed that the latent roots of the plane strain mentioned are proportionals to the principal radii of curvature of normal sections of the surface $f(x, y, z) = c$. The above differential equation of second order therefore expresses that every point of each of these surfaces is an umbilic. Hence the general solution consists of a system of spheres (or planes) with one variable parameter, ($u = A(x, y, z)$). The above quaternion method gives also the conditions that a system of lines may be the intersection of one pair of orthogonal systems of surfaces, or of an infinite number of such pairs.

The Calendar Group. By C. A. Waldo.

Linear Euthymorphic Functions of the First Order.

By E. M. Blake. (Abstract.)

Euthymorphic functions are those monogenic functions which satisfy an equation of the form

$$\phi(z) + p_1(z)\,\phi(f_1(z)) + \;.\;\;.\;\;.\; + p_n(z)\,.\,\phi(f_n(z)) + p(z) = o$$

where $f_1, \ldots, f_n, p_1, \ldots, p_n, p$ are given functions of which $p_1, \ldots, p_n, p$ are algebraic. The *order* of $\varphi(z)$ is n and it is *linear* if all of $f_1, \ldots, f_n$ are of the form $\dfrac{\alpha z + \beta}{\gamma z + \delta}$.

The paper gives a systematic compilation of the investigations of Babbage, Rausenberger, Koenigs and others upon functions defined by an equation of the form

$$\phi(z) = p(z)\,.\,\phi\left(\frac{\alpha z + \beta}{\gamma z + \delta}\right) \qquad (1)$$

(where $p(z)$ is algebraic) in so far as relates to their existence and analytical expression. The theorems of Koenigs relate to more general functions but they are only defined within a limited circle of convergence. The application of these theorems to euthymorphic functions and their continuation over the entire z-plane are believed to be new.

A tabulation of the results contained in the paper is as follows:

Every equation (1) can be reduced by a linear transformation to one of the three forms:

$$\varphi(z) = p(z)\,\phi(z+1) \qquad \text{I.}$$

$$\varphi(z) = p(z)\,\phi(e^{i\theta}z) \qquad \text{II.}$$

$$\varphi(z) = p(z)\,\varphi(\alpha z), \ |\alpha| < 1. \qquad \text{III.}$$

Sub-forms and their solutions, (f is any function),

I*a*. $\phi(z) = \phi(z+1)$; $f(e^{2\pi i z})$

I*b*. $\varphi(z) = b\,\varphi(z+1)$; $b^{-z}\,.\,f(e^{2\pi i z})$

I*c*. $\phi(z) = \dfrac{(z-a_1)\;.\;.\;.\;.\;(z-a_m)}{(z-b_1)\;.\;.\;.\;.\;(z-b_n)}\,\phi(z+1)$

$$;\ \frac{\Gamma(z-b_1)\;.\;.\;.\;.\;\Gamma(z-b_n)}{\Gamma(z-a_1)\;.\;.\;.\;.\;\Gamma(z-a_m)}\,.\,f(e^{2\pi i z})$$

I*d*. $\phi(z) = p(z)\,\phi(z+1)$; $p(z)$ irrational is unsolved.

II*a*. $\phi(z) = \varphi(e^{i\theta}z)$; $f(z^{\frac{2\pi}{\theta}})$

II*b*. $\varphi(z) = b\,\phi(e^{i\theta}z)$; $z^{-\frac{\log b}{i\theta}}\,.\,f(z^{\frac{2\pi}{\theta}})$

II*c*. $\phi(z) = p(z)\,\phi(-z)$; $(p(z).\ p(-z) = 1)$; $(1 + p(z))\,.\,f(z^{\frac{2\pi}{\theta}}.)$

For $p(z)$ not a constant IIc. is the only solved form.

IIIa. $\phi(z) = \varphi(az)$; $f(z^{\frac{2\pi i}{\log a}})$

IIIb. $\phi(z) = b\phi(az)$; $z^{-\frac{\log b}{\log a}} \cdot f(z^{\frac{2\pi i}{\log a}})$

IIIc. $\phi(z) = z\phi(az)$; $\prod_{m=0}^{\infty}(1 + a^m z) \cdot \prod_{m=1}^{\infty}(1 + \frac{a^n}{z}) \cdot f(z^{\frac{2\pi i}{\log a}})$

IIId. $\phi(z) = p(z)\phi(az)$; $(p(o) = 1)$; $\tau(z) \cdot f(z^{\frac{2\pi i}{\log a}})$.

The $\tau(z)$ has the same number of branches as $p(z)$. It may be algebraic. When transcendental ∞ is its only essential singular point.

The solution of any equation of form III. consists of a product of solutions of the four types given.

New Mechanical Computer. By Fred Morley.

A New Apparatus for Photographic Surveying. By Fred Morley.

Crushing Strength of Wrought Iron Cylinders. By W. K. Hatt and L. Fletemeyer.

Tests of a Wrought Iron Car Axle. By W. F. M. Goss.

While much has been written concerning the variety and intensity of the stresses which service conditions impose upon car axles, there have been presented but few descriptions of the behavior of such axles when under stresses that are simple and definite in character. Interesting material of the latter class is supplied by a recent test of a 60,000-pound axle made in the Engineering Laboratory of Purdue University.

The axle tested was supplied by the Bass Foundry and Machine Works, of Fort Wayne. It is said to have been made of No. 1 wrought railroad scrap, and to have been selected at random from a lot of 100 which were being shipped to a railroad company, and with it there was delivered to the laboratory a small test specimen which had been drawn down from the crop end of the axle. As prepared for the tests the axle carried two 33-inch cast wheels, and it was tested under transverse stresses, while the small specimen was subjected to tensional tests. The work was executed by Mr. J. H. Klepinger, who perfected details in the general plan and was painstaking in the manipulation of the apparatus.

The tests were made on a 300,000-pound Riehle testing machine, a general view of which, with the axle in place for testing, is shown by Fig. 1. Fig. 2 gives the dimensions of the axle and the details of the arrangements for applying loads. The axle was supported by cast iron blocks, AA, four inches in breadth, shaped to the form of a bearing, and extending from the center to the outer end of the journal. The actual points of support were located in the center of these blocks. Load was applied to the wheel treads through steel rollers, BB, which, at the beginning of the test, were located 4 feet 10 inches apart; that is, at a point corresponding to a position three-fourths of an inch outside of the inner or "gauge face" of the rail upon which it may be supposed the wheels were set to run. In this manner stresses were imposed upon the axle which were in every way similar to those which might have been imposed by a car, if the axle had been in service, but to give greater facility in testing, the usual order was reversed, the rails being assumed to be above the axle and the car below.

Fig. 2 shows also the means employed in determining the deflections corresponding to different loads. At each end of the axle there was attached a light arm (bb), extending at right angles both to the axle and to the plane of the stresses to which it was subjected. Over these was stretched a fine wire parallel to the axis of the axle. The wire passed through the web of the wheels, in holes which were drilled for the purpose, and made sufficiently large to give ample clearance. The whole length of wire between the arms (bb) was at all times perfectly free, and the arrangement was such that although the axle might be bent by loads applied to it, the wire would remain straight. Three micrometers attached to blocks clamped about the axle served to locate the latter with reference to the wire, and thus to determine the deflection. A fourth micrometer was used to measure distances between the wheels' flanges in a line parallel with the axle and 16½ inches distant from its center.

Loads were applied at C in 5,000 pound increments, and all micrometers were read before each change of load. In this way a maximum load of 85,000 pounds was applied, under which the axle showed unmistakable signs of failure, the elastic limit having been reached with a load of 55,000 pounds. The results are presented graphically by Fig. 3, in which the curve marked "center" represents the deflections of the center of the axle as determined by the middle micrometer, Fig. 2; the curves marked "right" and "left" represent corresponding deflections for points 18 inches either side of the center. Deflections of the axle involved changes in the gauge of the wheels as measured above or below the axle, the extent of which is indicated by Fig. 4.

The actual readings of all micrometers are given in the tabulated statement below:

LOAD.	Micrometer Readings at Different Loads.								Total Deflection.			
	Center.	Dif. of Center.	Left.	Dif. of Left.	Right.	Dif. of Right	Flange.	Dif. of Flange.	Center.	Left.	Right.	Flange.
	.084		.250		.176		.145					
5,000	.111	.027	.275	.025	.200	.024	.175	.030	.027	.025	.024	.030
10,000	.138	.027	.297	.022	.220	.020	.199	.024	.054	.047	.044	.054
15,000	.151	.013	.310	.013	.233	.013	.228	.029	.067	.060	.067	.083
20,000	.190	.039	.339	.029	.264	.031	.265	.037	.106	.089	.088	.120
25,000	.226	.036	.365	.026	.288	.024	.290	.025	.142	.115	.112	.145
30,000	.255	.029	.388	.023	.311	.023	.315	.025	.171	.138	.135	.170
35,000	.284	.029	.412	.024	.334	.023	.369	.054	.200	.162	.158	.224
40,000	.315	.031	.435	.023	.357	.023	.370	.001	.231	.185	.181	.225
45,000	.347	.032	.455	.020	.380	.023	.401	.031	.263	.205	.204	.256
50,000	.377	.030	.485	.030	.405	.025	.438	.037	.293	.235	.229	.293
55,000	.414	.037	.513	.028	.434	.029	.476	.038	.330	.263	.258	.331
60,000	.455	.041	.546	.033	.465	.031	.522	.046	.371	.296	.289	.377
65,000	.504	.049	.582	.036	.498	.033	.564	.042	.420	.332	.322	.419
70,000	.569	.055	.627	.045	.543	.045	.633	.069	.475	.377	.367	.484
75,000	.616	.057	.675	.048	.585	.042	.716	.083	.532	.425	.409	.571
80,000	.761	.145	.782	.107	.683	.098	.839	.123	.677	.532	.507	.694
85,000	.963	.202	.936	.154	.816	.133	1.068	.229	.879	.686	.640	.923

The dimensions of the axle were such (Fig. 2) that when loaded to its elastic limit, the maximum fiber stress at its center was 29,730; at 18 inches from the center 22,100 pounds, and at the neck of the journal 20,600 pounds.

The axle tested was designed for use under a freight car of 60,000 pounds capacity, the car itself weighing about 20,000 pounds. Each of the four axles under such a loaded car, therefore, must withstand a static load of 20,000 pounds, which load would develop a maximum fiber stress in the center of the axle tested of 10,810 pounds. In comparing these values with those obtained in the tests as given in the preceding paragraph, it is important to remember that the stresses to which car axles are subjected when in service arise from complicated conditions, and that their value can not be determined from static conditions alone.

The test specimen which was forged down from the crop end of the axle was turned down in the center for a distance of 8.5 inches and tested under tension. The results are as follows:

Diameter in inches	1.875
Area of cross section	2.755
Total load, pounds	140,700.
Ultimate strength, pounds, per square inch	51,070.
Elastic limit	30,000.
Modulus of elasticity	29,671,000.

Area at point of fracture—

Per cent. of original area.	61.6
Elongation in 8 inches, per cent...	27.3

Finally one end of the test specimen was exposed to the action of acids, and the etching thus produced used in printing Fig. 5. This figure, therefore, shows the disposition and relative density of the various layers of iron composing the specimen. The symmetrical arrangement of curved lines, which is so noticeable, is due evidently to the hammering of the round section of the axle to a square section in the process of forging the end of the axle down to the size of the test specimen.

While the tests show the iron of the axle to have been of excellent quality, the most significant fact developed is that concerning the amount of distortion which such an axle will withstand without taking a permanent set.

It would at first sight appear impossible that by loads applied at the journals a common car axle could be deflected at its center as much as a third of an inch without exceeding its elastic limit, but an analysis of the data given will fully justify such a conclusion. The results show also that a deflection of the axle well within the elastic limit of the material may be sufficient to produce a temporary change of gauge in the wheels mounted upon it of quite three-tenths (0.3) of an inch.

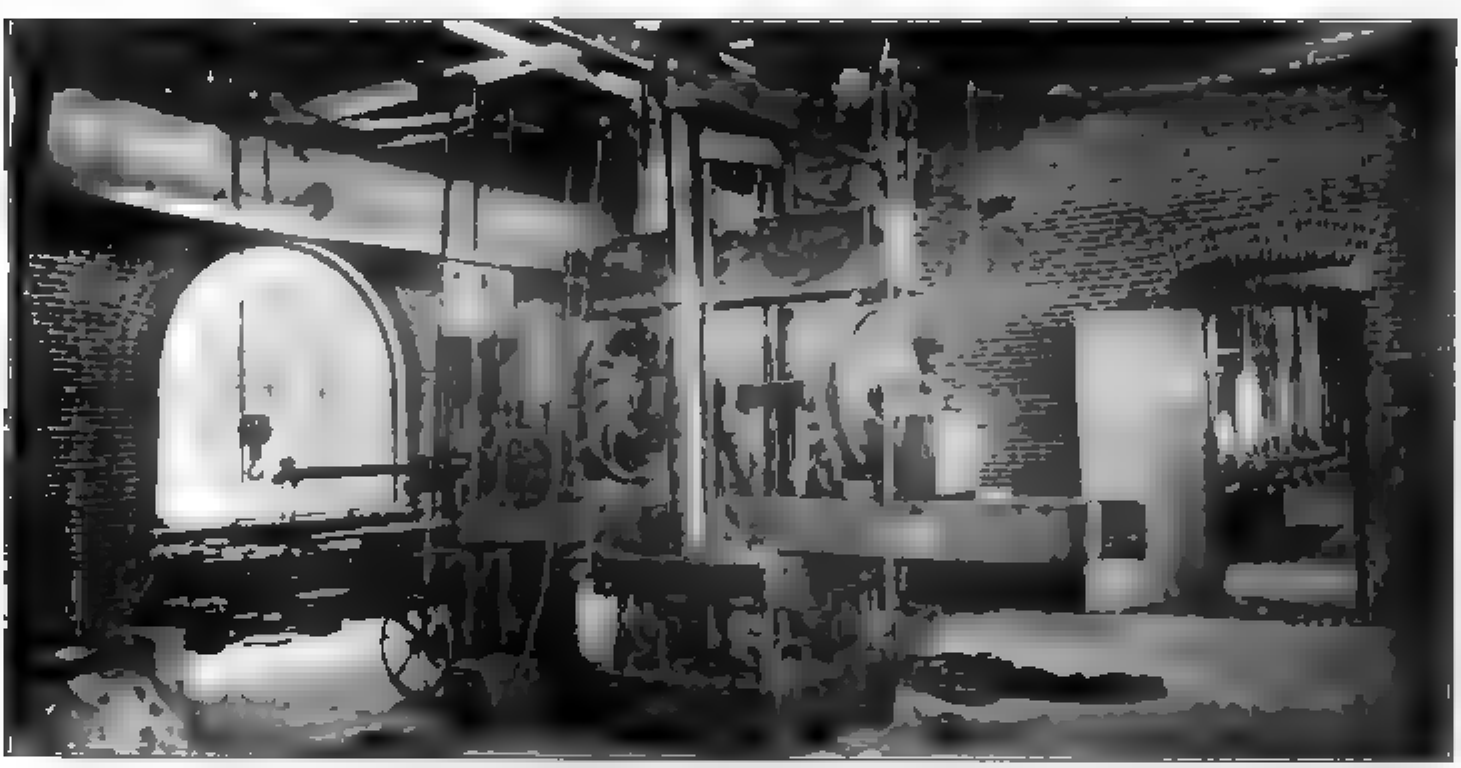

Fig. 1. Tests of a Wrought Iron Car Axle.

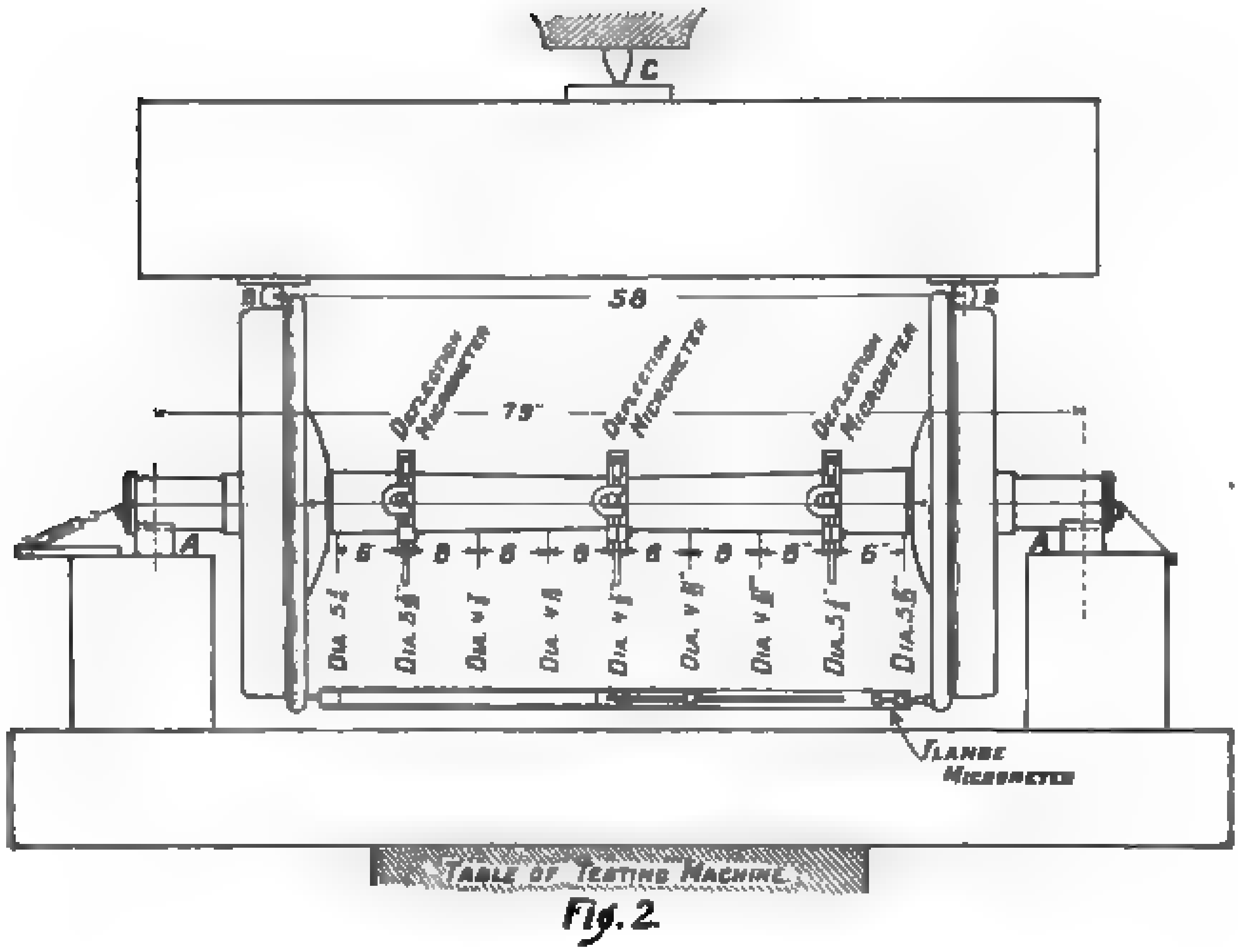

Fig. 2. Tests of a Wrought Iron Car Axle.

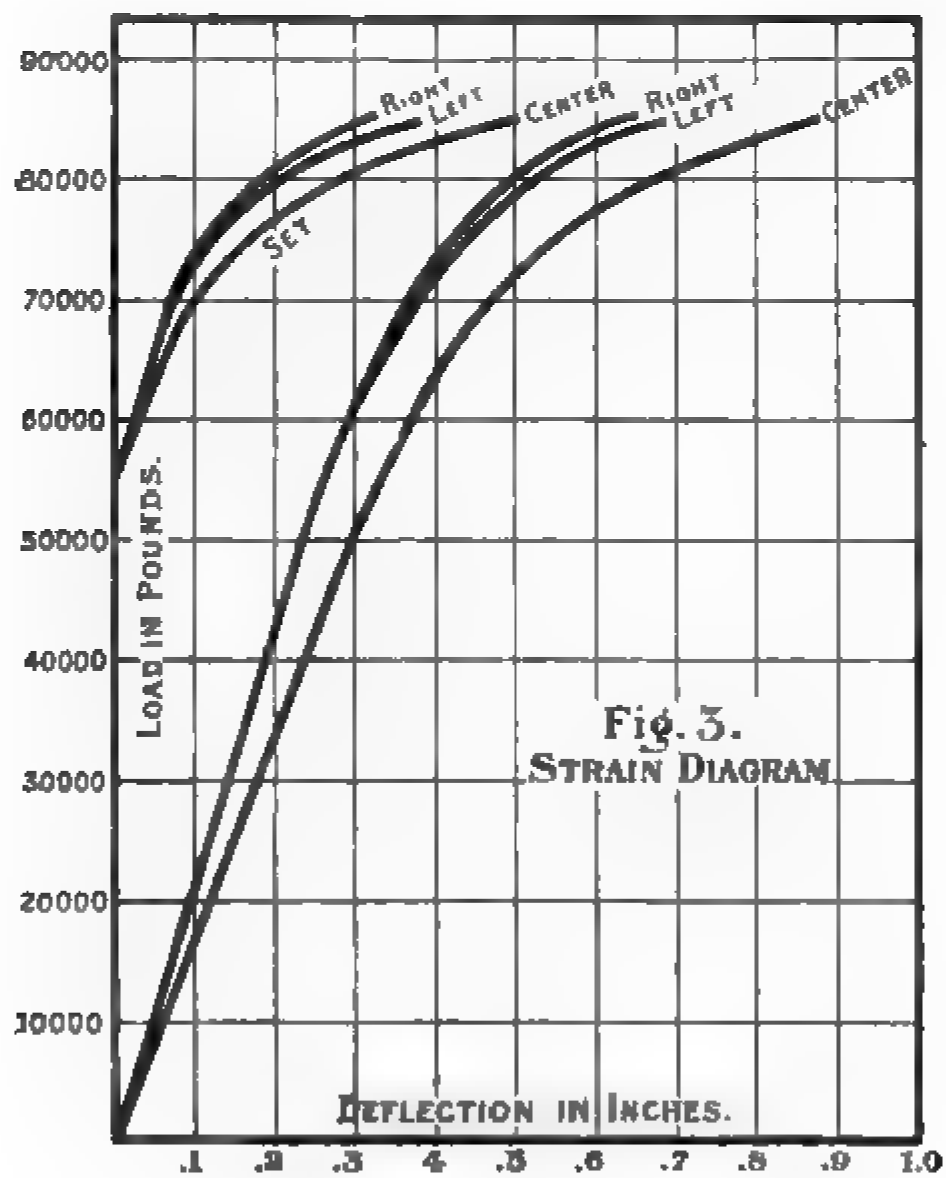

Fig. 3. Tests of a Wrought Iron Car Axle.

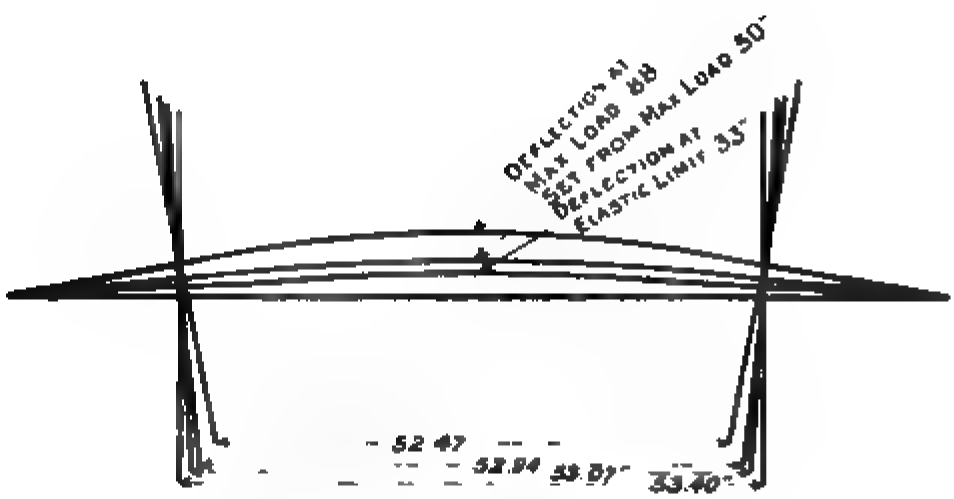

Fig. 4.

Fig. 4. Tests of a Wrought Iron Car Axle.

Fig. 5.

Fig. 5. Car Axle.

Subdivision of Power. By J. J. Flather.

While economy in the use of power should be secondary to increased output, yet careful attention to details will often greatly reduce the useless waste of power.

It is well known among engineers that there is a very great percentage of loss due to shaft friction, which, in shops where the buildings are more or less scattered, is probably not far from 75 per cent. of the total power used. In two cases known to the writer these losses are 80 and 93 per cent respectively.

No matter how well a long line of shafting may have been erected, it soon loses its alignment, and the power necessary to rotate it is increased.

In machine shops with a line of main shafting running down the center of a room, connected by short belts with innumerable countershafts on either side, often by more than one belt, and, as frequently happens, also connected to one or more auxiliary shafts which drive other countershafts, we can see why the power required to drive this shafting should be so large.

There is no doubt, however, that a large percentage of the power now spent in overcoming the friction of shafting in ordinary practice could be made available for useful work if much of the present cumbrous lines of shafting were removed.

Manufacturers are realizing the enormous loss of power which ensues from the present system of transmission, and we find a general tendency to introduce different methods by which a part of this loss will be obviated. Among these are the introduction of hollow and lighter shafting; higher speeds and lighter pulleys; roller bearings in shaft hangers; and the total or partial elimination of the shafting.

Independent motors are often employed to drive sections of shafting and isolated machines, and among these we find steam engines, electric motors, gas engines and compressed air motors, although the latter have not been used for this purpose to any extent in this country.

For the average machine shop, short lengths of light shafting may be employed to good advantage, and the various machines, arranged in groups, may be driven from one motor. By this method fewer motors are required and each may be so proportioned to the average load that it may be run most of the time at its maximum efficiency. When short lengths of shafting are employed the alignment of any section is very little affected by local settling of beams or columns, and since a relatively small amount of power is transmitted by each section, the shaft may be reduced in size, thus decreasing the friction loss. Moreover, with this arrangement, as also with the independent motor, the machinery may often be placed to better advantage, in order to suit a given process of manufacture; shafts may be placed at any angle without the usual complicated and often unsatisfactory devices; setting-up room may be provided in any suitable location as required without carrying long lines of shafting through space. This is an important consideration, for not only is the running expense reduced thereby but the clear head room thus obtained free from all shafting, belts, ropes, pulleys and other transmitting devices, can be more easily utilized for hoists and cranes, which have so largely come to be recognized as essential to economical manufacture.

There is also less liability of interruption to manufacture on account of the subdivision of power, and, in case of overtime, it is not necessary to operate the whole works with its usual heavy load of transmitting machinery.

Another advantage is the adaptability of the system to changes and extension; new motors may always be added without affecting any already in operation, and the ease with which this system lends itself to varying the speed of different unit groups is a very potent factor in its favor.

In the choice of motors for this work the steam engine has heretofore been used, especially where the units are relatively large. An interesting example of this is noted in the sugar refinery of Claus Spreckles, in Philadelphia, in which there are some seventy-five Westinghouse engines about the works, many of them being of 75 and 100 horse-power.

A similar subdivided plant involving forty-two engines was erected several years ago at the print works of the Dunnell Company, Pawtucket, R. I. More recently, however, the electric motor has superseded the steam engine for this work, as its economy and convenience over the latter is now thoroughly recognized.

For isolated machines and for heavy machines that may be in occasional use the electric motor is particularly well adapted as a source of power, for such a means of transmission consumes power only when the machine is in operation.

This is true also of compressed air, and we find numerous instances where it has entirely replaced steam even in large work. Thus, at the steel works at Terni, Italy, a 100-ton hammer is worked by compressed air, and also two large cranes, one having a capacity of 100-tons and the other 150 tons. Compressed air in some cases is also superseding steam for operating pumping machinery.

In Paris, according to Prof. Unwin, compressed air motors are even used to drive dynamos for electric lighting. At some of the newspaper offices there are motors of 50 and 100 horse-power driving presses, and in shops and factories these motors are used to run lathes, saws and various other machines.

In the transmission of air, within reasonable limits, the loss in transmission need not be considered, for although there is a slight loss in pressure due to the frictional resistances of the pipes, yet there is a corresponding increase in volume due to fall in temperature, so that the loss is practically inappreciable.

In the compression of air, with steam actuated compressors, there are various sources of loss, which, in the aggregate, will vary from 25 to 45 per cent. of the total power of the machine.

The greatest loss of efficiency is that in the air motor. It is usually impracticable to reheat the air with any degree of economy when employed intermittently, and we find very generally that the air is used at normal temperature for the various purposes to which it is applied. In small motors (1 to 2 horse-power) the loss may be as much as 65 per cent. when the air is used without expansion. With larger motors (75 horse-power), using a reheater and hot air jackets, the motor loss has been kept within 20 per cent. at full load.

These results and others would indicate that compressed air as now used is not at all efficient as a source of motive power, since the combined efficiency of compressor and motor, even under favorable conditions, is not more than 50 per

cent. of the available energy put into the compressor. In other cases the efficiency is as low as 20 per cent.

There should be no comparison between the cost of the transmission of power by compressed air and its so-called rival, electricity, since each has its own field of usefulness, yet it may be interesting to note for our present purposes the efficiency of electric transmission.

A modern generator, belted from an engine, will have an efficiency of about 90 per cent. when working under favorable conditions, but as the average load is ordinarily not more than two-thirds full load, and often much less, the efficiency will not usually be more than 85 per cent. Since the engine friction was added to the losses in compression, so also it should be considered here, in which case the efficiency of generation will lie between 75 and 80 per cent. With a pressure of 220 volts, which is very suitable for ordinary shop transmissions when both light and power are to be taken off the same line, the loss in transmission need not be more than 5 per cent. so that the efficiency at the motor terminals will not be far from 75 per cent. With motors running under a nearly constant full load the efficiency of motor may be 90 per cent., but with fluctuating loads this may fall to 60 per cent. at quarter load. In numerous tests made by the writer the average load on several motors in machine shops was only about one-third of the rated capacity of the motor.

It is interesting to note that in recent tests made at the Baldwin Locomotive Works it was found that with a total motor capacity aggregating 200 horse-power, a generator of only 100 horse-power was sufficient to furnish the current, and ordinarily only 80 horse-power was required.

Under these conditions when the driven machines are not greatly overmotored we may assume a motor efficiency of 80 per cent., which may be less or greater in individual cases. The combined efficiency, then, of generator and motor working intermittently with fluctuating loads will be about $75 \times 80 = 60$ per cent. of the power delivered to the engine.

For greater distances than those which obtain in plants of this character the loss in transmission will be greater, and higher voltage must be employed in order to keep down the line loss; while it is possible to put in conductors sufficiently large to carry the current with any assumed loss, yet the cost of the line soon becomes prohibitive with low voltage. In work of this kind it is well to remember that while the efficiency may be very high the economy may be very poor, and good engineering is primarily a question of good economy, all things considered. It is not the most efficient plant which produces the greatest economy. While it is interesting to know that a certain amount of power may

be transmitted a given distance with a high efficiency, it is more important to know that the same amount of power could be obtained at the objective point for one-fourth the cost of the former.

Lafayette, Ind., Dec. 30, 1896.

ECONOMY IN THE DESIGN OF ELECTRO-MAGNETS. BY W. E. GOLDSBOROUGH.

Published in the Electrical World, Vol. XXIX, p. 196, Feb. 6, 1897.

AN EFFICIENCY SURFACE FOR THE PELTON MOTOR. BY W. K. HATT.

Published in the Journal of the Franklin Institute, June, 1897.

ON SEICHES. BY A. W. DUFF.

SOME EXPERIMENTS ON THE PHENOMENA OF THE ELEVATION OF THE ELASTIC LIMIT. BY W. K. HATT.

VISCOSITY AS A FUNCTION OF TEMPERATURE. BY A. W. DUFF.

[Abstract.]

The author shows the insufficiency of the formulæ proposed by Poisenille, Slotte, Koch, Grätz and others, and finds generalized formulæ.

$$\left.\begin{aligned} \eta &= C\left(\frac{t+a}{t+b}\right)^n \\ \eta &= Ca^{-\tan^{-1}a(\beta+t)} \end{aligned}\right\}$$

which are in agreement with all data hitherto obtained, the former applying to water and most substances of slow variation of viscosity, and the latter to glycerine, mercury and most substances of rapid variation of viscosity.

Comparison of Clark and Weston Cells. By S. N. Taylor.

A great deal of work of very excellent character has been done upon the Latimer Clark Standard Cell by Prof. Glazebrook, Prof. Carhart, Prof. Kahle, Lord Rayleigh and others, and by them the merit of the cell has been well established.

It has been shown by them that the cell can be made so that, under favorable conditions, it will vary in E. M. F. less than one part in a thousand, even when made by different persons and of materials obtained from various sources. It has also been shown that with proper care the cell maintains its potential indefinitely, and forms a very excellent standard of electro-motive force, which is both moderately portable and cheap.

It is well known, however, that this standard of potential has at least one very serious drawback, namely, it has a very large temperature coefficient, and the E. M. F. of the cell varies considerably for slight changes in temperature. Moreover the coefficient may not be the same for different cells, or may be different at different temperatures even in the same cell, if the temperatures considered are not near together. Therefore the coefficient for any cell can be exactly determined only by experiment on that particular cell, and must be ascertained for all ranges of temperature to which the cell is likely to be exposed. It is also true that changes in temperature in the cell can not be detected easily and accurately, and hence arises some doubt as to the actual E. M. F. of a Clark cell at any particular instant.

Methods have been proposed for obviating this difficulty, but for want of space we must omit them here. It goes without saying, however, that if we could find another cell having the same excellencies as the Clark in all respects, and not having this defect in temperature coefficient, it would be a decided advantage.

The Cadmium cell, recently invented by Mr. Edward Weston, has attracted considerable attention, and so far as our observations go, it possesses these very qualifications. For the past three years we have spent considerable time in testing the merits of this cell as compared with the Clark Standard Cell.

To do this we made a number of Clark cells according to the latest instructions given by the English Board of Trade, as found in the Philosophical Transactions for 1892. We also made a number of Weston cells similar to the Clark, except that in the Cadmium or Weston cells Cadmium and Cadmium-Sulphate took the place of the Zinc and Zinc-Sulphate of the Clark.

Groups of cells were made at various times, and tests made upon them. We mention the group set up during March, 1895, as typical of all the Cadmium cells. They were of the H form (see Fig. 1) and constructed as follows:

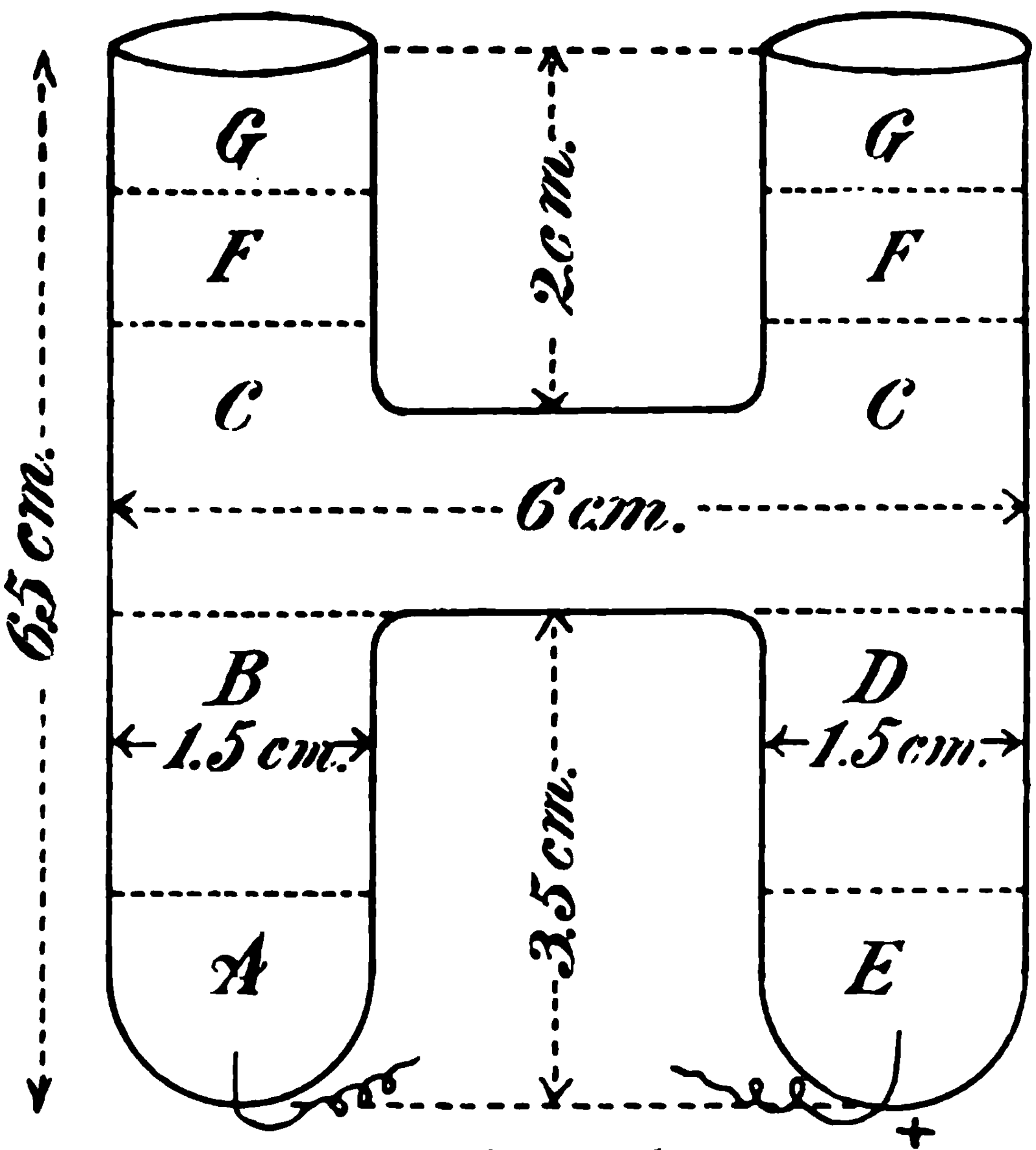

Fig. 1.

At *A* there is a quantity of Cadmium Amalgam about one centimeter deep, and covering the platinum wire, the negative terminal. Above this, at *B*, there is a concentrated solution of Cadmium Sulphate ($CdSO_4$) containing crystals of Cadmium Sulphate. At *E* there is pure mercury covering the platinum wire which serves as a positive terminal. Above the mercury, at *D*, there is a thick paste of Mercurous Sulphate (Hg_2SO_4), reaching as high as the cross tube. The remainder of the space, *CC* up to the corks *FF*, is filled with a solution of Cadmium Sulphate. The tubes are then sealed above the corks in the usual manner by marine glue or some other form of cement. I can not describe here the manner in which these materials were prepared, but can only refer those interested in the subject to a dissertation which I am about to publish concerning my investigations at Clark University. Suffice it to say that the mercury used was some which I had purified a short time before by means of chemicals and distillation in vacuo;

and the other materials were bought of Eimer & Amend as being chemically pure. The cells are easily made, and can be set up by anyone without much trouble.

The method adopted for comparing these cells one with another was a modification of the potentiometer method used by Professor Kahle, and was as follows:

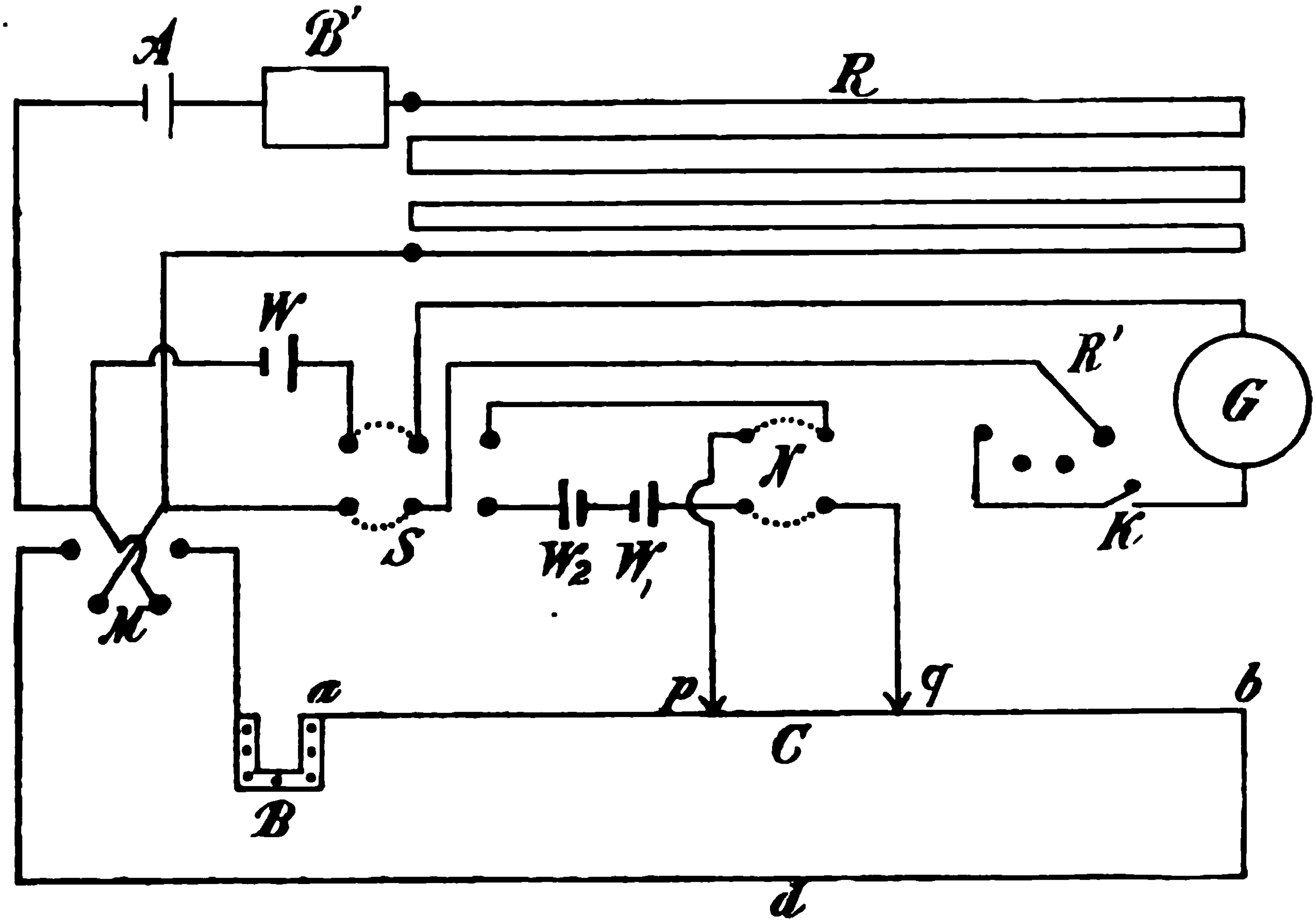

Fig. 2.

The current from a single storage cell A (Fig. 2) passes through an ordinary resistance box B^1 and through a wire resistance R made of German silver, with sliding contact capable of continuous variation for fine adjustment. At the mercury commutator M the circuit is divided. The first branch passes through B, then through the wire c back through d and M to the storage cell A. The second branch of the circuit passes successively from M through the transfer switch S, the variable resistance R^1, the sensitive galvanometer G, back again to S, and thence through W to M. The resistance box B was made especially for this purpose and consists of seven coils of wire, having the resistances of 10, 15, 50, 100, 300 and 500 ohms approximately. These dip into a dish of kerosene, so that their temperature can be measured more readily. C is a German silver wire 1,122 mms. long, stretched tightly over a boxwood meter bar. The resistances of both

B and c have been very accurately measured in international ohms and their temperature coefficients determined. W is a standard cell, either a Clark or a Weston, and is connected in opposition to the storage cell A. As the current then passes from A, if the resistance in B is properly adjusted, the E. M. F. of W will just counterbalance the potential around the B-branch and there will be no deflection of the galvanometer G when the key K is closed. But increasing the resistance in B, if A is constant, has the same effect upon the potential around the B-branch as decreasing the resistance in R would have. Hence we may choose any resistance in the B branch that we may wish, and yet regulate the potential about that branch by properly adjusting the resistance in R. This being true, let B denote the total resistance of the B-branch, including c and d; let c denote the resistance of the wire $a\ b$; let E_w denote the E. M. F. of the standard cell W and E_c the potential about the wire a, b or c. Then, when the resistance in B^1 and R are so adjusted that we get no deflection of the galvanometer G when K is closed, we have the proportion:

$$B : C :: E_w : E_c$$

Knowing the resistance c of $a\ b$ and that of the total B-branch, of course we know the potential about c. Again, since the potential between any two points $p\ q$ between $a\ b$ increases directly as the resistance included between them, and since the resistance increases directly as the distance between the points, we can find any portion of the potential E_c by measuring off on the meter bar the appropriate length along the wire $a\ b$.

Another portion of the potentiometer consists of a third branch circuit including two standard cells W_1 and W_2 which are to be compared. For short we shall call this branch the N-branch. It starts from a movable contact p on the wire $a\ b$ and leads to the reversing commutator N, thence through W_1 and W_2 to S through the galvanometer G back again through N to q, another movable contact on $a\ b$. p and q are knife-edged contacts and can be placed at any position along the wire $a\ b$ and the distance between them measured by means of the meter rod.

The two cells W_1 and W_2, which are to be compared, are now placed in this branch in opposition to each other. If, then, the E. M. F. of W_1 is exactly equal to that of W_2, that is if $E_1 = E_2$, and if p and q are placed close together upon C, then there will be no deflection of the galvanometer G when K is closed. If, however, E_1 is greater than E_2 we can find two points upon C such that the difference in potential between p and q shall exactly equal the difference between E_1 and E_2 and in opposite directions. The potentials in the N-branch will then be at equilibrium, and there will be no deflection of the galvanometer. In other

words, we thus measure the difference between E_1 and E_2 in terms of the standard cell W. This is expressed by the formula

$$E_1 - E_2 = n \frac{E_w C}{l B} = n k$$

Where E_w = E. M. F. of the cell W; E_1 = E. M. F. of the cell W_1;
E_2 = the E. M. F. of the cell W_2
n = number of millimeters between p and q
l = total length of the wire ab in millimeters
c = resistance of the wire ab
B = total resistance of the B-branch
k = $\frac{E_w C}{l B}$ or the constant of the wire ab.

The resistance of R^1 consists of a few coils of wire varying in resistance from zero to fifty thousand ohms, but their actual resistance need not be known. Neither is it necessary to know the resistance at B^1 and R, nor that of the galvanometer G, since the method of no deflection is used. Care was always taken, however, never to close the circuit through the galvanometer without including a high resistance at R^1, unless it was first known that the system was almost exactly at equilibrium. For it is important that as little current as possible shall be allowed to pass through the cells. But when the system has been carefully adjusted, the resistance of R^1 can be gradually cut out, so as to utilize the full sensitiveness of the galvanometer. Measurements made by means of this apparatus were limited in accuracy only by the galvanometer's sensitiveness. For by taking the resistance in B large enough we can make k as small as we please. Thus we found that we were able to detect differences in E. M. F. as small as three one-millionths ($\frac{3}{1000000}$) of a volt with a considerable degree of certainty.

One difficulty whicb we had to overcome was the change in position of the galvanometer's zero, caused by the passing of electric street cars some four hundred feet distant. It was found necessary to make the final measurements between 12:30 and 5:30 A. M., when the cars were not running.

Measurements made at various times upon a number of Clark and Weston cells are given in the following table:

TABLE No. 1.

VARIATIONS OF E. M. F. OF CLARK AND WESTON CELLS IN $\frac{1}{100000}$ VOLTS.

	Date of Measurement.	Mar. 16, 1895.	Mar. 18, 1895.	Mar. 22, 1895.	Apr. 15, 1895.	Apr. 17, 1895.	Apr. 18, 1895.	June 17, 1895.	Oct. 25, 1895.	May 29, 1896.
	Temp.	18.°8C.	19.°8.	20.°0.	19.°0.	20.°2.	20.°0.	23.°2.	19.°6.	20.°0.
Cells made October, 1894	C_5	....	....	....	C_s + 13.0	C_s + 20.3	C_s + 17.8	C_s + 37.6	....	....
	C_6	....	....	....	....	....	....	C_s + 60.2	C_s + 49.6	....
	C_7	....	....	....	C_s + 46.5	C_s + 74.3	C_s + 86.7	C_s + 42.8	C_s + 74.9	....
	C_8	....	....	....	C_s − 10.9	C_s − 15.1	C_s − 15.1	C_s − 64.4	C_s − 49.6	....
	C_9	....	....	....	C_s − 11.5	C_s − 14.2	C_s − 4.5	C_s − 45.9	C_s − 49.6	....
Cells made March, 1895	W_7	W_n − 15.1	W_n − 16.3	W_n − 21.1	W_n 8.8	W_n 10.3	W_n + 9.1	W_n 13.8	W_n + 7.2	W_n 3.0
	W_9	W_n + 21.1	W_n + 24.6	W_n + 12.1	W_n − 5.4	W_n − 4.5	W_n − 4.8	W_n 4.8	W_n − 7.8	W_n 1.9
	W_{10}	W_n − 24.5	W_n − 23.9	W_n − 39.2	W_n − 23.6	W_n − 22.3	W_n − 23.6	W_n 4.2	W_n − 3.0	W_n 1.9
	W_{11}	W_n − 8.2	W_n + 14.2	W_n + 12.1	W_n + 3.9	W_n 3.6	W_n 4.5	W_n 1.2	W_n − 2.4	W_n 7.6
	W_{12}	W_n + 64.3	W_n + 74.0	W_n + 40.8	W_n + 19.3	W_n 13.9	W_n + 16.0	W_n 12.6	W_n + 11.1	W_n 14.1
	W_{13}	W_n 72.5	W_n + 5.5	W_n − 3.0	W_n − 2.7	W_n − 3.0	W_n − 3.0	W_n 3.0	W_n − 5.7	W_n 1.9
	W_{14}	W_n + 7.6	W_n − 3.0	W_n − 13.8	W_n − 8.5	W_n − 7.0	W_n − 9.1	W_n − 7.2	W_n − 3.0	W_n 4.2
Cells made May 31, 1895	W_{15}	....	....	....	....	....	....	W_n 27.1	W_n + 22.3	W_n + 7.6
	W_{16}	....	....	....	....	....	....	W_n 18.4	W_n + 7.5	W_n − 2.7
	W_{17}	....	....	....	....	....	....	W_n + 25.5	W_n + 9.6	W_n + 5.7
	W_{18}	....	....	....	....	....	....	W_n + 30.7	W_n + 15.1	W_n 4.6
	W_{19}	....	....	....	....	....	....	W_n + 18.4	W_n + 5.1	W_n 5.6

From this table it will be noticed that when the Cadmium cells are first set up they differ somewhat in E. M. F. But after about a month they come to have a normal value which is common to all. Moreover, this value is not affected by any moderate change in temperature, and so far as our experience goes, these cells are more easily made, and there is less variation in E. M. F. between them than there is between the Clark cells.

It will be noticed that the values given in Table No. 1 are simply relative, but we have made absolute determination of their E. M. F., and find for the Weston cell the value 1.01851 volts when the resistance is measured in Legal ohms; or 1.015633 volts when the resistance is measured in International ohms.

The result of our investigations lead to the following conclusions:

First. That the Cadmium cell is more easily constructed than the Clark cell.

Second. That it has practically no temperature coefficient.

Third. That the E. M. F. of the Cadmium cell is even less variable than that of the Latimer Clark.

Soil Solvents for Available Potash and Phosphoric Acid. By H. A. Huston and J. M. Barrett.

It seems to be accepted that in the case of worn soils solution in strong mineral acid gives little insight into the availability of their potash and phosphoric acid. More recently the use of dilute organic acids, such as the one per cent. citric acid used br Dr. Bernard Dyer[1] and the acid ammonium oxalate used by Dr. A. M. Peter[2], has been tried with more promising results. The theory of the use of dilute organic acid solutions seems to rest on the idea that plant roots give off fluids containing organic acids which act on the soil in a degree comparable with the effect of the dilute acids employed in the laboratory experiments.

While I do not question that plant roots in contact with polished marble, or even granite, may make appreciable markings on the carbonate of lime and on the feldspar of the granite, the conditions of the experiment, as usually conducted, differ radically from those found in the field, for in the experiment the plants are not supplied with normal soil water. So far as I have observed, normal soil waters give an alkaline reaction. No inconsiderable part of the food of the plants comes to it dissolved in the soil waters. The work of Dr. H. J. Wheeler[3] shows what marked difficulty is encountered in growing plants on a well-drained soil having an acid reaction.

Soil waters rising from a subsoil are charged with more or less of mineral salts; and if the upper layers of the soil have a different composition from the lower layers in which the soil waters have been charged, we may expect chemical changes to take place according to the well established facts of soil absorption.

In view of these considerations some work was undertaken with alkaline solvents. The first solution used contained the same amount of ammonium oxalate as the solution used by Dr. Peter; but instead of the acid an amount of ammonia equivalent to the acid was added. All work is based on the same relative quantities of soil and solution as used by Dr. Peter—200 grams soil and 1,000 cc solution. In working with Dyer's solution the digestions continued at room temperature for seven days, with shaking at frequent intervals. All the other digestions were continued for five hours, with constant shaking in the apparatus described in Indiana Agricultural Experiment Station Bulletin 55, and Wiley's Principles and Practice of Agricultural Analysis, Volume II, page 142. The flasks were inverted every thirty seconds. The utmost care was used to secure clean precipitates of potassium platinic chlorid.

THE SOILS USED.

The Kentucky soils are those used for work by the Association of Official Agricultural Chemists for the past two years, and are described on page 31 of Bulletin 47, Chemical Division United States Department of Agriculture. Briefly stated, the soil requires the addition of potash to produce satisfactory crops of corn, potatoes and tobacco, but seems to contain enough available potash for a good wheat crop. The field tests indicate abundance of available phosphoric acid. Soil No. 1 has received phosphoric acid and nitrogen, and Soil No. 2 has received potash and nitrogen. Of the Indiana soils the one marked "Turley" is from Orange County. It is a medium clay resting on a red clay, which in turn rests on the limestone rock of the region.

The land has been under cultivation for some seventy years, and at one time was so badly worn as to be considered of very little value. The sample was drawn after plowing for corn in the spring of 1896. In 1895 wheat had been so poor on this land that hogs were turned in to eat the standing crop. In the spring of 1896 the clover was so uneven that the land was put in corn, of which it produced in this very favorable year for corn, thirty-seven bushels per acre on the unfertilized plats. The owner does not believe that it can produce a profitable crop of wheat without the use of some commercial fertilizer or manure. The usual application has been one hundred pounds ground bone per acre. The field tests this year showed marked gain in corn from the use of acid phosphate and

potash, but increasing the amount of potash from thirty to sixty pounds per acre gave no increased yield. Original timber, oak.

The soil marked "Campbell" is from Monroe County, and represents a cold, badly drained clay, resembling the so-called "crawfish" clay. Commercial fertilizers are considered necessary for wheat. Field tests this year showed marked gains on corn from the use of acid phosphate and potash, but increasing the amount of potash from thirty to sixty pounds per acre gave no increased yield. Original timber, poplar and mixed hard woods.

The station land is a second-bottom soil, resting on gravel. It is a dark, productive loam. In favorable seasons the land will produce fifty bushels of corn and thirty bushels of wheat per acre without the use of fertilizers or manure. While commercial fertilizers have some effect in increasing the crops, the use of them on this land has not been profitable. Original timber: Black walnut, oak, maple, wild cherry and some hickory. The plats from which the samples were drawn have been in wheat since 1888. Plats 3 E. 1 and 3 E. 4 have received no fertilizers; plat 3 E. 2 has received "complete" chemical fertilization, and plat 3 E. 5 has received applications of barnyard manure. In five years (1890 to 1894), 3 E. 1 lost to crop 8.1 pounds phosporic acid, 11.3 pounds potash, and 17.8 pounds nitrogen; plat 3 E. 4 lost 7.2 pounds phosphoric acid, 10.1 pounds potash, and 15.9 pounds nitrogen; plat 3 E. 2 lost net 0.8 pounds phosphoric acid, 3.2 pounds potash, and 7.9 pounds nitrogen; plat 3 E. 5 gained 4.2 pounds phosporic acid, 6.9 pounds potash, and 0.3 pounds nitrogen. The plats contain one-tenth acre each. Plat 3 E. 4, a blank plat, contains humus (by Huston's method) 45.3 per cent., and nitrogen in this humus 4.52 per cent. Plat 3 E. 5, which has received barnyard manure, contains humus 5.6 per cent., and nitrogen in this humus 5.71 per cent.

The mechanical analyses of the Indiana soils are shown in Table 1.

TABLE I.

SOURCE.	Gravel.	Coarse Sand.	Sand.	Silt.	Clay.	Moisture and Organic.	Total.
	%	%	%	%	%	%	%
Turley	0.25	0.16	7.05	39.82	47.64	5.31	100.23
Campbell	1.57	.67	12.23	45.02	35.21	5.08	99.78
Station 3 E. 4	1.56	2.56	13.95	35.42	36.54	9.94	99.97

Since Peter's solution and the alkaline ammonium oxalate contain a salt of ammonia, it was thought that the phenomena of soil absorption might come into play. To test this, a solution of the same alkalinity, but containing the same amount of ammonia as chloride as was contained in the other solutions in the form of oxalate, was used. To test the question of soil absorption pure and simple, a neutral solution of ammonium chlorid, 17.2 grams to the liter, the same amount of ammonium chlorid as in the previous solution was used.

The soils were also digested with ammonium hydrate, sp. gr. 0.96, containing 17.2 grams ammonium chlorid per liter, and with ammonium hydrate, sp. gr. 0.96 alone. Ammonium hydrate was tried, because, as I have previously shown[5], phosphates of iron and alumina are dissolved by ammonium hydrate. At first we hoped to utilize the ammonia and ammonium chlorid mixture, but in the presence of the ammonium chlorid not a trace of phosphoric acid was dissolved.

On the Kentucky soils a number of solvents were tried at a higher temperature. This modification seemed no improvement—rather the reverse; and it was decided to use room temperature.

Table II contains the results of the work. The total potash in each soil, and the amount of potash and phosphoric acid removed by hydrochloric acid, sp. gr. 1.115, are also added for the purpose of comparison:

TABLE II.

SOURCE OF SAMPLE.		Dyer's Solution 1% Citric Acid (Room Temp.; 7 Days).	Peter's Solution (Room Temp.; 5 Hrs.)	Alkaline Am. Oxalate (Room Temp.; 5 Hrs.)	Peter's Solution (65° C.; 5 Hrs.)	Alkaline Am. Oxalate (65° C.; 5 Hrs.)	Alkaline Am. Chloride (65° C.; 5 Hrs.)	Ammonia Sp. Gr. 0.96 (Room Temp.; 5 Hrs.)	17.2 Grams Am. Chloride in 1 Liter Ammonia Sp. Gr. 0.96 (Room Temp.; 5 Hrs.)	17.2 Grams Am. Chloride in 1 Liter Water (Room Temp.; 5 Hrs.)	17.2 Grams Am. Chloride in 1 Liter 1% Hcl. (Room Temp.; 5 Hrs.)	Ammonia Sp. Gr. 0.96 (Room Temp.; 20 Hrs.)	N/5 Calcium Chloride (Room Temp.; 5 Hrs.)	Ammonia 2% (Room Temp.; 5 Hrs.)	Ammonia 2% (Room Temp.; 20 Hrs.)	Alkaline Am. Chloride (Room Temp.; 5 Hrs.)	Total Potash by J. L. Smith Method.	Soluble in Hcl. Sp. Gr. 1.115 on Steam Bath.
Kentucky:																		
No. 3 potash and nitrogen	P_2O_5	(.0541)	.0628	.0138	.0492	.0222	0	.0337	0	0	......	......	......	......	......	0	......	.431
	K_2O	(.0069)	.0189	.0226	.0185	.0173	.0196	.0140	.0162	.0238	......	......	......	......	......	.0176	1.485	.340
No. 1 phos. acid and nitrogen	P_2O_5	(.0560)	.0776	.0165	.0565	.0195	0	.0352	0	0	......	......	......	......	......	0	......	.432
	K_2O	(.0038)	.0183	.0144	.0200	.0135	.0165	.0148	.0137	.0218	......	......	......	......	......	.0134	1.467	.317
No. 1-No. 3	P_2O_5	(.0019)	.0148	.0027	.0073	.0027	0	.0015	0	0	......	......	......	......	......	0	......	.001
No. 3-No. 1	K_2O	(.0031)	.0015	.0082	.0015	.0038	.0031	.0008	.0025	.0020	......	......	......	......	......	.0042	.0018	.023
Indiana:																		
Turley	P_2O_5	.0028	.0031	.0025	......	......	......	.0025	0	0	.0026	.0076	0	.0077	.0131	0	......	.056
	K_2O	.0321	.0370	.0262	......	......	......	.0083	.0274	.0398	.0400	.0266	.0161	.0132	0	.0248	2.147	.354
Campbell	P_2O_5	.0073	.0303	.0016	......	......	......	.0035	0	0	.0102	.0112	0	.0125	.0112	0	......	.045
	K_2O	.0244	.0232	.0161	......	......	......	.0058	.0152	.0257	.0269	.0158	.0130	.0086	0	.0188	1.898	.283
Experiment Station:																		
3 E. 1 blank plat	P_2O_5	.0047	.0553	.0157	......	......	......	.0304	0	0	.0074	.0249	0	.0290	.0348	0	......	.124
	K_2O	.0267	.0244	.0150	......	......	......	.0073	.0177	.0331	.0251	.0098	.0123	.0082	0	.0176	1.958	.450
3 E. 2 chemical fertilizer	P_2O_5	.0053	.0530	.0156	......	......	......	.0298	0	0	.0039	.0182	0	.0423	.0364	0	......	.118
	K_2O	.0258	.0254	.0180	......	......	......	.0067	.0183	.0309	.0298	.0185	.0104	.0094	0	.0259	1.876	.470
3 E. 4 blank plat	P_2O_5	.0025	.0447	.0140	......	......	......	.0227	0	0	.0016	.0205	0	.0339	.0342	0	......	.121
	K_2O	.0246	.0275	.0155	......	......	......	.0082	.0186	.0319	.0318	.0119	.0112	.0100	0	.0136	1.955	.447
3 E. 5 manure	P_2O_5	.0019	.0479	.0157	......	......	......	.0231	0	0	.0051	.0262	0	.0358	.0335	0	......	.107
	K_2O	.0268	.0314	.0158	......	......	......	.0104	.0218	.0354	.0391	.0160	.0134	.0094	0	.0300	2.035	.471

It will be seen that Dyer's solution and Peter's solution resemble each other in a general way in their action on the phosphates of the Kentucky soil (rich in phosphates) and on the Turley soil (poor in phosphates); while on the Campbell land (poor in phosphates), and on the station land (fairly good in phosphates) they differ radically.

In their action on potash the two solutions differ widely in the case of the Kentucky soils containing too little available potash for corn, while they resemble each other in their action on the other soils, which seem from field tests with corn to contain considerably higher available potash than the Kentucky soils.

Dyer's solution extracts more phosphoric acid from the Kentucky soil that had received phosphoric acid than from the one receiving none. From the station soil it extracts the highest phosphoric acid from the soil that had received superphosphate; but it failed to extract as much phosphoric acid from the soil receiving its phosphoric acid in the form of manure as it extracted from either of the plats that had received no fertilizers. On the average, Dyer's solution extracts no more phosphoric acid from the station soils known to contain a fair supply of available phosphoric acid than from the clay soils known to be very deficient in phosphoric acid.

Dyer's solution dissolves more potash from the Kentucky soil that had received potash than from the one not receiving any.

From the clay soils, which seem from field tests with corn to be somewhat deficient in available potash, it dissolves relatively high amounts of potash. From the station soils it dissolved no more potash from the soil that had received full applications of muriate of potash than from the soils that had received no potash.

Peter's solution would indicate that there was a good supply of available phosphoric acid in the Campbell soil, where it is known to be deficient. It would also indicate that the Turley land was higher in available potash than the station soil, although the field tests indicate to the contrary.

The acid solutions of Dyer and Peter seem to fail when applied to soils of different types, although their indications are in the right direction when applied to soils of exactly the same type, such as the Kentucky soils.

The alkaline ammonium oxalate dissolves practically as much potash from the Kentucky soil as from the station soil, although the available potash is much higher in the latter, as shown by field tests.

It dissolves about the same amount of phosphoric acid from the Kentucky soil as from the station soil, both of which have a fair amount of available phosphoric acid, although the former has a much higher total phosphoric acid content. It distinguishes these soils very sharply from the clay soils known to be deficient in phosphoric acid.

The alkaline ammonium chlorid distinguishes the fertilized from the unfertilized plats very sharply on the station soil and to a fair extent on the Kentucky soil. Its action on the clay lands is in accord with what knowledge we have in regard to the potash in these soils.

The ammonium chlorid dissolved in ammonia, sp. gr. 0.96, gives results on potash in the same general direction as the mildly alkaline ammonium chlorid, but the differences are less sharply defined. As this solution is rather troublesome to work with, I would prefer to use the mildly alkaline one.

The neutral ammonium chlorid distinguishes very well the Kentucky soil from the station soil, gives fair indications on the clay soils, but fails to show the effect of the potash salts applied to the station soil.

Ammonium hydrate, sp. gr. 0.96, gives results on potash that are quite at variance with what is known about these soils, but on phosphoric acid it gives promising results. The character of the individual results indicates that the digestion was not continued long enough to complete the reaction. Yet the results clearly distinguished the lands poor in phosphoric acid from those known to be well supplied with available phosphoric acid. The only case where it seems at fault is on plat 1 of the station soil. But every other solvent acts in the same way, indicating that the sample from this plat is really higher in phosphoric acid than the sample from the other blank plat, No. 4. Crop tests covering five years show that plat 1 has a crop-producing capacity about 15 per cent. greater than plat 4.

Ammonium chlorid in neutral and alkaline solution removes notable quantities of lime from soils. The quantities were determined and are given in Table III.

TABLE III.

PER CENT. OF CALCIUM OXID REMOVED BY VARIOUS SOLVENTS.

SOURCE OF SAMPLE.	By alkaline ammonium chlorid (5 hours; room temp.).	By neutral ammonium chlorid (5 hours; room temp.).	By HCl., sp. gr. 1.115 (10 hours on steam bath).
Kentucky No. 3	0.144	0.173	6 0.51
Kentucky No. 1	.122	.196	6 .31
Turley	.066	.122	....
Campbell	.114	.143	....
Station 3 E. 1	.096	.216	....
Station 3 E. 2	.089	.246	....
Station 3 E. 4	.113	.226	.447
Station 3 E. 5	.105	.227	.472

It will be seen that the alkaline ammonium chlorid removes about one-fourth and neutral ammonium chlorid about one-half as much lime as the hydrochloric acid used in the customary method of soil analysis. The station soils are practically free from carbonates, containing an average of only 0.015 per cent. of carbon dioxid.

Of the solvents used we consider alkaline ammonium chlorid and neutral ammonium chlorid promising for available potash, and ammonium hydrate promising for available phosphoric acid. Alkaline ammonium oxalate seems to do very well for available phosphoric acid in some cases, but the material is rather troublesome to work with on account of the large amount of organic matter that goes into solution. Where ammonium chlorid is present the solutions are nearly free from organic matter, filter very rapidly, and the ignition is readily made, leaving only a small amount of bases to be removed before determining the potash. Tatlock's method was tried for potash, but proved unsatisfactory.

We have tried chlorids of calcium, magnesium, and sodium, but prefer to use the ammonium salt, since it introduces no involatile base which would interfere with the potash determination.

We are now at work with ammonium hydrate, continuing the digestion for a longer time and changing the strength of the solution. We are also testing ammonium chlorid dissolved in 1 per cent. hydrochloric acid. We shall also test

the question of the relative quantities of the soil and solvents used as the present amounts—200 grams soil to 1 liter of solvent—seems to involve too small a volume of solvent. While we feel encouraged by the outcome of the work reported above, it must be borne in mind that before any method of soil testing can be considered satisfactory, it must give reliable indications on soils of different types that have been subjected to investigation by field tests; and these tests must not be confined to one crop, but must relate to all the crops likely to be produced on the land under investigation. From data now at hand it seems probable that certain soils may have ample potash in an available form to produce good crops of cereals, while not having enough to produce profitable crops of corn, potatoes, or tobacco. This phase of the matter must be kept in mind in deciding upon any definite amount of soluble ingredients which shall be used as a minimum in judging of the fertilizer needs of a soil.

Purdue Agricultural Experiment Station, November, 1896.

(1) Jour. Chem. Soc., London, March, 1894. This paper contains a resume of suggestions by various authors and special investigations by Dr. Dyer.

(2) Chem. Div. U. S. Dept. Agr., Bull. 47, p. 32.

(3) Rhode Island Agr. Exp. Sta., 7th Ann. Rpt., p. 152.

(4) Chem. Div. U. S. Dept. Agr., Bull. 38, p. 84; Wiley's Agr. Analysis, vol. 1, p. 326.

(5) Chem. Div. U. S. Dept. Agr., Bull. 31, p. 99.

(6) Determined by Harry Snyder. See Bull. 47, U. S. Dept. Agr., Chem. Div., p. 49.

Action of Ammonium Citrate and Citric Acid on Basic Slag. By H. A. Huston and W. J. Jones, Jr.

[Abstract.]

This is a continuation of the work carried on for several years by the authors under the general head of the availability of commercial phosphates. This paper deals with the two most prominent materials proposed for determining the availability of the phosphoric acid in the slag. The factors controlling the action of the reagents are discussed under the following heads:

I. Influence of time of digestion.
II. Influence of temperature.
III. Influence of acid (citric) and alkali (ammonia).
IV. Influence of quantity of slag used.

V. Action of citric acid on slag.

Amount of acid neutralized in times ranging from one-half to five hours, at 25° C and at 65° C. Amount of phosphoric acid remaining in solution at the end of these periods. The phosphoric acid in solution decreases with a rise in temperature and with an increase in time.

VI. Comparison of the U. S. official method with the method proposed by Dr. Paul Wagner, including special molybdate and magnesia solutions.

The paper will be found in complete form in Bul. 49, Chem. Div. U. S. Dept. Agr., p. 68-72.

Laboratory State Chemist of Indiana, Purdue Univ., Nov., 1896.

The Character of the Volatile Matter Lost by Bituminous Coals at 100° C. By W. E. Burk.

The conditions accompanying the common method of determining moisture in coal suggested a study of the nature and amount of volatile matter given off at the temperature of determination.

The work was done on two classes of Indiana coals, one high in moisture, the other considerably lower, the operation consisting in passing the volatile products from the coal heated approximately to 100° C, together with a current of dry air over copper oxide in a combustion furnace, absorbing the moisture coming over with calcium chloride, and carbon dioxide arising from combustion of any volatile hydrocarbons in a caustic potash solution.

A hard glass combustion tube was used, which extended some 20 c. m. from the forward end of the furnace. This portion of the tube was jacketed with a glass sleeve with rubber plugs, and arranged with entrance and exit openings through which a continuous current of steam was passed. By this means a temperature approximating 100° C was maintained through the forward part of the tube in which a weighed quantity of powdered coal was placed in an aluminum boat. A slow current of dry air was passed, and the heating of coal and combustion of volatile products maintained for one hour. The boat was then removed and the absorption bulbs weighed, after which they were attached again and the tube heated for a further twenty to thirty minutes. The boat containing coal was weighed in a glass enclosing tube, and after the operation was allowed to cool in

same tube and under similar conditions, thereby preventing any reabsorption of moisture while cooling.

Determinations were made on from one to three grams of coal, giving results of which the following are fair examples:

Weight of Coal Taken.	Loss in Weight of Coal at 100° C.	Gain in Weight of Each Tube.	Moisture.	Carbon Found From K O H Absorption.
1.4217 gr.	.1994	.2014	14.00%	.048%
1.1195 "	.1596	.1625	14.25%	.058%
3.1079 "	.2111	.2113	6.78%	.022%
3.2356 "	.2152	.2142	6.65%	.025%
2.9408 "	.1967	.1967	6.65%	.037%

The gain in weight of the calcium chloride tube corresponds with a slight difference to the loss in weight of the coal, giving per cent. of moisture, which agreed very well with separate determination of moisture in the same coals by the ordinary method of heating for one hour in a toluene bath, results being slightly higher, due perhaps to current of air passing over coal, removing moisture more completely.

The gain in weight of the calcium chloride tube exceeded the loss in weight of the coal more than what would arise from the combustion of any volatile hydrocarbons present, as indicated by carbon found and calculated as methane. This excess of water found may indicate presence of free hydrogen, but a correct explanation of its presence, as well as of the source of carbon found, can not be made without an accompanying analysis of the gases given off from the coal at 100° C, as the small percentage of carbonic oxide, carbon dioxide and hydrocarbon volatilized at 100° varies widely with different coals. The per cent. of volatile hydrocarbons given off in these experiments —.029% to .077%—calculating as methane, is probably higher than occurs in the regular determination of moisture because of the air current, while on the other hand the somewhat lower temperature of these experiments would tend to modify the difference. As in no case, however, does the loss of volatile matter other than water nearly reach one-tenth of one per cent., the error in calculating the same as moisture is of no practical importance.

Notes on Diphenylselenon and Selenthren. By Robert Lyon.

Notes on L— and B— Lupanin. By Sherman Davis.

The Physiological Action of Compounds Containing Bivalent Carbon. By J. U. Nef.

The Calculation of the Heating Effect of Coals from the Proximate Analysis. By W. A. Noyes.

So far as I am aware, no satisfactory formula has ever been given for the calculation of the heating effect of coals from the amounts of fixed carbon, volatile combustible matter and sulphur present. It has been generally assumed that the amount of oxygen in coals varies so greatly that no rational basis for such a calculation could exist. During the spring of 1895, Mr. J. R. McTaggart and Mr. H. W. Caver made careful analyses and determined the heating effect with Hempel's calorimetre, for six Indiana coals. Recently I have had the opportunity of examining similar analyses and calorimetric tests of fifteen Pittsburgh coals, made under the direction of Prof. N. W. Ford, of the University of Ohio.

In the analyses as given, the amount of oxygen in these coals appears to vary between quite wide limits. On subtracting from the total oxygen the oxygen present in the form of water, however, it was found that the average amount of *oxygen of combustible matter* was 7.72 per cent. for the Indiana coals and 8.05* for the Pittsburgh coals, or a general average of 7.96 per cent. and a maximum deviation from that average of 1.23 per cent. In only one coal is the difference from the mean more than one per cent.

Since the per cent. of hydrogen in these coals is subject to only a slight variation, it follows that the combustible matters present in all of these coals so far as they consist of carbon, hydrogen and oxygen, have a nearly constant composition. There should, therefore, be a nearly constant factor for this total combustible matter. In order to calculate this factor for the coals in question it has been assumed that one-half of the sulphur is found in the volatile combustible matter as calculated from the difference between total volatile matter and water, and that the fixed carbon is given with sufficient accuracy by subtracting the ash from the coke. In other words, the combustible matter was formed for the purposes of this calculation by subtracting from 100 the per cents. of water and ash

* In calculating this result Professor Ford's figures for oxygen were corrected by adding three-eighths of the weight of sulphurs, on the supposition that iron pyrites in the coal is burned to ferric oxide in the ash. See Jour. Am. Ch. Soc. XVII.

and one-half of the per cent. of sulphur. When the heating effect, as found in the calorimetre (calculated on the basis of the fuel burned and vapors of water at 100° C.) was divided by this per cent. of combustible matter it was found that one gram of combustible matter gives, on the average, for the Indiana coals 8073 calories and for the Pittsburgh coals 8078 calories.

We may, therefore, give the following empirical rule for the calculation of the heating effect of coals: *Find the combustible matter by subtracting from 100 the per cents. of water and ash and one-half of the per cent. of sulphur, and multiply this remainder by 80.7. The result will give the heating effect of the fuel burned to liquid water.*

For the twenty-one coals referred to, the heating effect calculated by this rule shows a maximum deviation from the calorimetre test of two and one-fourth per cent., while the agreement is in most cases, much closer than that.

It would not be safe to apply this rule to coals known to be of very different origin or character, until a similar comparison of calorimetre results with the analysis has been made for such coals.

Notes on the Flora of Lake Cicott and Lake Maxinkuckee. By Robert Hessler.

The following notes on the flora of the region surrounding Lakes Cicott and Maxinkuckee are offered as a contribution toward a complete flora of Indiana; they are based on personal observations made during the period beginning with August, 1894, and ending with December, 1896.

Longcliff, just west of Logansport, has been the basis of operation, so to speak, and this locality has been examined most fully. I thought it best, therefore, to make mention of the noteworthy plants found here, although the flora does not differ materially from that common to the central part of the State. It is the usual glacial drift flora, with beech as the most common forest tree.

The region about the lakes is in marked contrast. The upland soil is made up of a fine sand which contains only the merest trace of lime, and with oak as the prevailing tree. The lowlands in places are wet or swampy. Tamarack swamps and peat bogs occur here and there, but are nowhere of great extent. It is, perhaps, unnecessary to state that the wet northern portion of Indiana is being drained more and more every year, and the land, exceedingly fertile, brought under cultivation. The completion of the Kankakee drainage system will, in time, be followed by numerous minor systems, and in the course of a few years the

"Marsh Flora," if we may so call it, will have disappeared from Indiana. Already many of the plants, once common, are rare and restricted to isolated areas; the natural habitat being destroyed, the extermination of plants naturally follows. In my own numerous excursions I have, in many instances, been unable to find more than one or two specimens of certain species after three seasons of close search. The reports of other observers in different parts of the State show a similar result. Even now the swamps and bogs mentioned in this paper are being ditched and drained, and in a very short time the last vestiges of a once common flora will have disappeared.

The flora of the uplands, with, perhaps, a few exceptions, is in no immediate danger of extinction. It will be many years before the comparatively barren oak flats and oak ridges will be brought under cultivation, and even then species will continue to lead a more or less precarious existence in waste places and along fence rows. Species with showy flowers, or those that are useful, are among the first to disappear; this being especially true of the flora of lakes visited by summer tourists.

A few remarks on the location and general surroundings of the chief localities embraced in this paper will render unnecessary in the notes extended references to localities, which would otherwise be frequent. For instance, "Swamp east of Lake Cicott" refers to one definite locality, as described below.

LAKE CICOTT is located near the western border of Cass County, about eight miles west of Logansport. At present it is an oval body of water less than half a mile in length, east to west. Formerly it was much larger, with an irregular shore line. The north and south banks are high, even bluffy; those on the east and west low and flat. There is no outlet, but in the event of high water the excess would drain into Crooked Creek, a mile to the east. The recession of the water has been in the west, and this portion is now dry and covered by a dense growth of weeds, chiefly ragweed and smartweeds. The water is very clear and contains few aquatics. The soil of the neighborhood is sandy, a fine-grained æolian sand with little lime, and with a vegetation characteristic to such soils, chiefly oak, with an entire absence of beech. The country is gently rolling, becoming level to the west and north. The railroad station at the lake is Cicott, also spelled Ciecott.

SWAMP EAST OF LAKE CICOTT is situated about one mile due east of the lake, and marks approximately the boundary between the sandy lands on the west and the glacial drift soils on the east. At present it is reduced to a few acres, and is being rapidly encroached upon by drainage, and will soon cease to be. The number of rare species found in it is remarkable; some were seen nowhere else.

Lake Maxinkuckee. This well-known lake, several miles in length, is located in the southwest corner of Marshall County, about thirty-five miles north of Logansport. The soil in the vicinity is sandy, especially in the uplands. The most interesting botanical localities are along the low marshy southern extremity, and, unless otherwise indicated, my references are to this part.

Tamarack Swamp, South of Delong, is located in the extreme northwest corner of Fulton County, within half a mile of the station on the Michigan Division of the Vandalia Railroad, and a few miles south of Lake Maxinkuckee. It has an irregular outline, is narrow in places and contains several hundred acres. In the center is the remains of an old lake, now almost covered over by a mass of ericads and peat moss. The whole region has recently been ditched, the ditch in places passing through peat four feet in thickness. This drainage is an example of what is going on all over northern Indiana.

Tamarack Swamp, East of Monteray, is several miles west of the last named swamp, and just east of the little town of Monteray, in Pulaski County. It covers less than fifty acres, but is very dense, and also contains the remains of a lake.

Sandy Land, West of Logansport, is interesting, botanically. It begins abruptly at Kenneth, three miles west of Logansport, in the form of a triangle, widening from a narrow point to a mile or more, and gradually fading or disappearing at Logansport. Geologically it is a limestone ridge covered with wind-blown sand in a glacial region. At the western extremity it rises abruptly, as already indicated, and is more or less bluffy on the sides, especially on the south, fronting the Wabash River. From a height of about forty feet at the angle, it gradually declines to the east and finally merges into the ordinary 'second bottom' soil of the valley. The sandy covering, that is, the soil, is deep on the north and very thin on the south, the underlying rock being bare in places. The Western portion is covered with a thin oak wood; the remainder is in cultivation. Certain species occurring here plentifully are either absent in the other localities or occur sparingly.

The Wabash River at Logansport, and for many miles below, has its bed eroded in the limestone; the bluffs in places are perpendicular and often twenty-five feet high; the bottom is of solid rock, sandbars being few and small. The periodical high water washes out everything before it, and, therefore, plants usually found on the sandy banks of rivers are notably absent.

Localities other than the above are referred to by name or descriptively under the proper species. Where no locality is given the species is general.

In regard to species included and excluded, the list is limited as follows:

(a.) To phanerograms or flowering plants.

(b.) Plants new to Indiana, *i. e.*, plants not given in Coulter's Catalogue of the Plants of Indiana.

(c.) Plants rare in Indiana, or locally distributed, according to the above catalogue.

(d.) Plants noteworthy for some particular reason.

(e.) Excluded species are those common throughout the State and which may be seen at any time. At the suggestion of Prof. Stanley Coulter, however, some species have been mentioned on account of their rarity or absence, an absence well marked to one accustomed to note the plants about him.

The nomenclature is that of the sixth edition of Gray's Manual, as at present used by the State Biological Survey. For the benefit of the reader not familiar with the botanical names the common English names have been added.

Specimens of species mentioned, unless common in other parts of the State, are in my herbarium. A set comprising those new to the State, and a number of the rarer ones, has been presented to the Biological Survey. In case of doubt as to the identity of a species, critical comparisons were made with the specimens in the herbarium of Purdue University. My thanks are due to Prof. Stanley Coulter for his kind assistance in making comparisons and in determining several species which were in leaf only.

Anemone Pennsylvanica L. General but nowhere abundant.

Anemonella thalictroides Spach. Rue Anemone. Common in sandy soils west and north, rare in drift soils.

Thalictrum polygamum Muhl. Tall Meadow Rue. Seen occasionally in wet soils about the lakes.

Ranunculus multifidus, var. *terrestris*, G. Two plants only found in a dried-up pool on the western border of Lake Maxinkuckee. None of the leaves were filiform.

Ranunculus sceleratus L. Cursed Crowfoot. Frequent in the brooks about Logansport; not seen at the lakes.

Isopyrum biternatum T. and G. Plentiful in beech woods, rare in sandy soil woods.

Caltha palustris L. Marsh Marigold. Frequent in wet places.

Coptis trifolia Salisb. Goldthread. Common in one small locality, tamarack swamp at DeLong; does not occur at Lake Cicott. No other notes.

Caulophyllum thalictroides Michx. Blue Cohosh. Rare in drift.

Jeffersonia diphylla Pers. Twin-leaf. Not seen; absent.

Brasenia peltata Pursh. Water-shield. Common in Lake Cicott; no notes on other localities.

Nelumbo lutea Pers. Water Chinquapin. Absent.

Nymphæa reniformis D. C. White Water Lily. Lakes, ponds and slow streams; common.

Nuphar advena Ait. Yellow Pond Lily. With the last, plentiful.

Sarracenia purpurea L. Pitcher Plant. Common in tamarack swamps around Lake Maxinkuckee. Not seen at Lake Cicott.

Corydalis flavula D. C. Plentiful about Logansport in all soils.

Arabis hirsuta Scop. Frequent along the banks of the Wabash. Plants smoothish; stems clustered. Not given in Coulter's catalogue.

Arabis dentata T. & G. Frequent on dry limestone cliffs and in hilly drift.

Erysimum asperum D. C. Western Wall Flower. Common on a few limestone cliffs west of Logansport.

Sisymbrium canescens Nutt. Tansy Mustard. Very common in the sandy lands west of Logansport, not seen in other localities.

Polanisia graveolens Raf. Noticeably absent from the banks of the Wabash River, and not seen anywhere.

Helianthemum Canadense Michx. Frost-weed. Frequent in dry, sandy soils about the lakes.

Lechea major Michx. Pinweed. Seen in two localities only, and here plentiful; one at Lake Cicott, in moist, sandy ground; the other east of Monterey.

Lechea minor L. A few plants seen near Lake Cicott; one locality.

Viola pedata L. Bird-foot Violet. Plentiful on sand ridges at Lake Cicott.

Solea concolor Ging. Green Violet. Rare, on limestone, west of Logansport.

Cerastium arvense Var. *oblongifolium* H. & B. Common in the Wabash Valley.

Hypericum prolificum L. Shrubby St. John's Wort. Rarely seen; east of Lake Cicott only.

Hypericum cistifolium Lam. In several places; wet limestone ledges on the Wabash; plentiful where it does occur.

Geranium Carolinianum L. A weed along the railroads.

Xanthoxylum Americanum Mill. Prickly Ash. Frequent in drift.

Ilex verticillata G. Winter Berry. Frequent about the lakes.

Nemopanthes fascicularis Raf. Frequent in tamarack swamps at DeLong; not seen anywhere else.

Rhamnus lanceolata Pursh. A few bushes on the limestone outcrops west of Logansport.

Ceanothus Americanus L. New Jersey Tea. Common everywhere in dry, upland, sandy soils; not seen in drift.

Vitis Labrusca L. Fox Grape. Rare; about the lakes.

Negundo aceroides M. Box Elder. In drift soils, rare.

Rhus venenata D. C. Poison Tree. Poisin Dog-wood. Excessively common about DeLong in tamarack swamps and peat bogs. Not seen at Lake Cicott. Its presence in a swamp acts as an effectual barrier to the entrance of many persons, especially those readily susceptible to its noxious influence. Many persons proof against the common Poison Ivy readily succumb to this species.

Rhus Canadensis Marsh. Fragrant Sumach. Very common and forming thickets in the thin, sandy soils west of Logansport and in the limestone ledges. Rarely seen in other localities.

Polygala Senega L. Seneca Snakeroot. Common in sandy soils east of Lake Cicott; more or less general in sand soils, but nowhere common.

Polygala sanguinea L. Rarely seen, in moist alluvial soils at lakes.

Polygala cruciata L. A few plants in one locality only, a moist place southeast of Lake Cicott.

Lupinus perennis L. Wild Lupine. Common about the lakes.

Psoralea onobrychis Nutt. Rare, in sandy soils.

Amorpha canescens Nutt. Lead Plant. Seen occasionally at Lake Cicott. No notes on its occurrence in other localities.

Petalostemon violaceus M. Rare; in sandy soils.

Petalostemon candidus M. With the last and rare.

Tephrosia Virginiana Pers. Goat's Rue. Lake regions; rare.

Astragalus Canadensis L. Along the west shore of Lake Maxinkuckee; not rare.

Desmodium canescens D. C. In sandy soils.

Lespedeza violacea Pers. Common in sandy soils west of Logansport; also occasional in other places.

Lespedeza reticulata Pers. Sandy woods of lake regions; frequent.

Lespedeza capitata M. With the last and common.

Lespedeza angustifolia Ell. A single large, bushy plant was found along the railroad east of Lake Cicott; perhaps a migrant.

Vicia Caroliniana Walt. Sandy soils about the lakes; frequent. Several other species, belonging apparently to the *Vicieæ* group, were found in leaf only, and on account of their uncertain identity are here excluded.

Apios tuberosa M. Absent.

Gymnocladus Canadensis Lam. Coffeenut Tree. Seen occasionally in drift soils at Logansport: trees often large.

Prunus Americana Mar. Wild Plum. Rare.

Prunus Virginiana L. Choke Cherry. Limestone bluffs; rare.

Spiraea salicifolia L. Common Meadow Sweet. Common in wet situations about the lakes.

Spireae tomentosa L. Hardhack. Steeple-bush. With the last, but rare.

Spiraea lobata Jacq. Queen of the Prairie. With the preceding.

Physocarpus opulifolius Maxim. Nine-bark. Rare; along Crooked Creek.

Potentilla Norvegica L. A weed in cultivated ground; common in drift.

Potentilla fruticosa L. Shrubby Cinquefoil. In a few places near the lakes, and here common.

Pyrus arbutifolia Var. *melanocarpa* Hook. Choke-berry. Frequent in low lands at the lakes.

Amelanchier Canadensis T. & G. Service-berry. Generally distributed, but rare.

Amelanchier Canadensis Var. *oblongifolia* T. & G. Dwarf June-berry. On limestone cliffs of the Wabash; not rare.

Saxifraga Pennsylvanica L. Meadow Saxifrage. Frequent in wet places.

Parnassia Caroliniana Michx. Abundant in many wet places.

Ribes floridum L'Her. Wild Black Currant. Seen occasionally in wet woods near Logansport.

Drosera species. Although a very close search was made for species of Drosera, not a single plant was found.

Hamamelis Virginiana L. Witch-hazel. None seen.

Liquidamber Styraciflua L. Sweet Gum. Seems to be absent.

Myriophyllum. No notes.

Lythrum alatum Pursh. Loosestrife. Common near the water's edge Lake Cicott; less common at Lake Maxinkuckee; moist places along the Wabash.

Decodon verticillatus Ell. Swamp Loosestrife. I have no specimens and no notes on its occurrence, but at this writing (December, 1896) believe it occurs in at least one wet place near Lake Cicott. I may add, parenthetically, that it occurs plentifully at Turkey Lake, in the northeast portion of Kosciusko County.

Epilobium angustifolium L. Great Willow Herb. A single large specimen of this handsome plant was found on the edge of the Tamarack Swamp at DeLong. Not in Coulter's Catalogue.

Heracleum lanatum Michx. Cow-Parsnip. Moist places about Lake Cicott; not rare.

Eryngium yuccaefolium Michx. Rattlesnake Master. Frequent about the lakes, especially Lake Cicott.

Aralia racemosa L. Spikenard. In drift soils; rare.

Viburnum acerifolium L. Dockmackie. Common in sandy soils.

Triosteum perfoliatum L. Horse Gentian. Rare.

Triosteum angustifolium L. Common in sandy soils. (Besides these well-marked forms there occur, especially in the sandy soils west of Logansport, specimens that partake of the characters of both. In a large collection all stages of transition of one to the other may be seen. Are possibly hybrids.)

Houstonia caerulea L. Bluets. Only two plants were found, one of which was in bloom, on the grassy edge of a thin sandy woods, about one mile south of Lake Cicott. The leaves are very hairy.

Houstonia purpurea L. A narrow-leaved form is common in the sandy lands west of Logansport; also seen about the lakes.

Galium boreale L. Northern Bedstraw. Noticed in three localities. Common in the swamp east of Lake Cicott and also common on the southern edge of Lake Maxinkuckee; rare on the wet limestone ledges just west of Logansport, on the Wabash. The occurrence in Cass County greatly extends its southern range in Indiana, according to Prof. S. Coulter.

Valeriana edulis Nutt. Common in a wet meadow on the southeast edge of Lake Maxinkuckee and in the swamp east of Lake Cicott, seen nowhere else. This species is not reported in Coulter's Catalogue.

Valerianella radiata Dufr. According to my notes, occurs along the railroad east of Cicott, but I can not vouch for its identity; no specimens preserved.

Eupatorium sessilifolium L. Upland Boneset. Occasional in sandy lands west of Logansport.

Liatris scariosa Willd. Frequent in dry sandy soil.

Liatris spicata Willd. Common in wet situations.

Grindelia squarrosa Dunal. Appearing along the railroads.

Solidago latifolia L. Broad-leaved Goldenrod. Rare.

Solidago uliginosa Nutt. Wet places.

Solidago speciosa Nutt. Rare; in sandy lands west of Logansport and in the neighborhood of Lake Cicott; not seen elsewhere. This showy species is not reported in Coulter's Catalogue of the Plants of Indiana.

Solidago patula Muhl. Common in wet places.

Solidago rugosa Mill. Collected at Lake Maxinkuckee in the fall of 1894. No notes.

Solidago ulmifolia Muhl. Common in thin woods, sandy lands west of Logansport.

Solidago arguta Ait. With the last, rare.

Solidago serotina Ait. Collected at Lake Maxinkuckee. No notes.

Solidago nemoralis Ait. Frequent in dry places at Lake Cicott.

Solidago radula Nutt. Collected at Lake Maxinkuckee.

Solidago rigida L. Some large plants at Cicott; frequent.

Solidago Ridellii Fr. Common in wet places.

Solidago lanceolata L. Common.

Solidago tenuifolia Pursh. At Lake Cicott; rare.

(Besides the above several Solidagos of doubtful identity were collected in different localities. Where no locality is given in the list the species occurs generally. These remarks also apply to the Asters. Asters are not represented as well as the Solidagos.)

Aster Novæ-Angliæ L. Common in wet places.

Aster azureus Lindl. Wet meadow east of Cicott.

Aster cordifolius L. Frequent.

Aster laevis L. Frequent.

Aster umbellatus Mill. Very tall and common in a wet place east of the Kenneth Stone Quarries, west of Logansport; rare at Lake Maxinkuckee.

Aster linariifolius L. Occurs sparingly on the southern high, dry, sandy bank of Lake Cicott; not found elsewhere.

Silphium terebinthinaceum L. Frequent; open, sandy soils.

Silphium laciniatum L. The Rosin-weed was not seen by me, but a friend brought me some leaves from the extreme northwest corner of Cass County; is reported common on the prairies to the northwest.

Silphium integrifolium Michx. Frequent about Lake Cicott.

Parthenium integrifolium L. Very rare; a few plants south of Cicott.

Ambrosia psilostachya D. C. Seen in leaf only; along the Vandalia Railroad at Marmont; evidently a migrant. Not in Coulter's Catalogue.

Echinacea purpurea Moench. Purple Cone-Flower. Generally distributed, but not common.

Rudbeckia subtomentosa Pursh. About Lake Cicott; rare.

Lepachys pinnata T. & G. General, but rare.

Helianthus occidentalis Rid. In dry places, Lake Cicott; rare.

Helianthus divaricatus L. Sandy woods west of Logansport; rare.

Coreopsis palmata Nutt. High south bank, Lake Cicott; rare.

Coreopsis tripteris L. Sandy woods; common.

Dysodia chrysanthemoides Lag. Along the railroad at Cicott; evidently a migrant. Not seen elsewhere.

Artemisia caudata Michx. High, sandy bank, Lake Cicott; rare; a few plants only. Not seen elsewhere.

Cacalia atriplicifolia L. Dry, sandy soil, along the railroad, east of Lake Cicott; possibly a migrant.

Cacalia tuberosa Nutt. Tuberous Indian Plantain. Swamp east of Lake Cicott only, and here common.

Cnicus arvensis Hoffm. Canada Thistle. Noticed a small patch at Logansport by the side of the railroads; is a migrant.

Prenanthes racemosa Michx. East of Cicott; rare. Not in Coulter's Catalogue, but reported since then.

Lactuca scariola L. Prickly Lettuce. This rank weed is excessively common along the railroads, and is rapidly spreading.

Lobelia cardinalis L. Not seen; if present at all, is certainly rare. (Common at Turkey Lake, in Kosciusko County.)

Lobelia spicata Lam. Frequent in dry, sandy soils.

Lobelia Kalmii L. Not rare in wet places.

Campanula rotundifolia L. Var. *Arctica.* Harebell. Common in crevices in limestone bluffs on the Wabash; frequent on high banks of Lake Maxinkuckee. Not seen at Lake Cicott.

Gaylussacia resinosa T. & G. Black Huckleberry. Common in open, sandy woods about the lakes.

Vaccinium Pennsylvanicum Lam. Dwarf Blueberry. Seen in one locality, a thin, sandy woods south of Lake Cicott. Doubtless occurs in other localities.

Vaccinium corymbosum L. Common or Swamp Blueberry. Common in swamps in sandy regions; not found in drift soil.

Vaccinium macrocarpon Ait. Cranberry. Common in open places in the tamarack swamps and peat bogs south of Lake Maxinkuckee. Not at Lake Cicott. According to the accounts of old settlers, very large cranberry bogs existed when the country was first occupied. The bogs or marshes now existing are small and are rapidly disappearing.

Epigaea repens L. Arbutus. Not seen.

Gaultheria procumbens L. Wintergreen. Frequent in low, damp woods about the lakes.

Andromeda polifolia L. With the Cranberry and Pitcher-Plant, in peat bogs chiefly; common where it does occur. Not in Coulter's catalogue.

Cassandra calyculata Don. Leather-Leaf. With the last; common.

Monotropa uniflora L. Indian Pipe. Rare; east of Lake Cicott.

Monotropa Hypopitys L. Pine-sap. Rare; with the last.

(No other members of the Heath family were seen.)

Dodecatheon Meadia L. Shooting-Star. A few plants in a wet meadow east of Cicott. Not seen in other localities.

Trientalis Americana Pursh. Star-Flower. In tamarack swamps; common where it does occur.

Steironema ciliatum Raf. General, but nowhere abundant.

Steironema longifolium G. In swamps; common.

Lysimachia stricta Ait. Plentiful in a small swamp south of Lake Cicott; no notes on its occurrence elsewhere.

Apocynum androsaemifolium L. Spreading Dogbane. General in sandy soils, and common along the railroads.

Apocynum cannabinum L. Indian Hemp. Not as frequent as the last.

Asclepias verticillata L. About the lakes; rare.

Acerates longifolia Ell. On the high, sandy, south bank Lake Cicott.

Sabbatia angularis Pursh. This handsome plant is common on the moist, sandy shores of Lake Cicott, and was not seen in any other locality.

Gentiana crinita Froel. Fringed Gentian. General in wet places, but not common.

Gentiana quinqueflora Lam. Not seen.

Gentiana Andrewsii Grisb. Closed Gentian. Rare; in moist woods.

Gentiana alba Muhl. A single plant in seed found in the summer of 1895 east of Lake Cicott.

Frasera Carolinensis Walt. American Columbo. A score or so of plants occur in the dry, sandy woods west of Logansport; not seen elsewhere.

Menyanthes trifoliata L. Buckbean. In bogs with the Pitcher-plant and Cranberry; common here.

Phacelia bipinnatifida Michx. In the Wabash Valley about Logansport, on rocky and hilly places; common; very fetid.

Phacelia Purshii Buckley. Common in cultivated grounds at Logansport as a weed; this year it bloomed freely in the fields at Longcliff up to November 27, not having been injured by a previous temperature of 22 degrees.

Mertensia Virginica D. C. Virginia Cowslip, Bluebells. In two localities in the valley west of Logansport; rare.

Lithospermum arvense L. Wheat-thief, Corn Gromwell. A weed common along the railroads, and has taken possession of some fields.

Lithospermum hirtum Lehm. Common in sandy soils.

Echium vulgare. The Viper's Bugloss, or Blue-weed. Occurs along the B. & O. Railroad east of Turkey Lake, in Kosciusko County; it will quite likely soon appear in this region.

Chelone glabra L. Turtle-head. Frequent in wet places.

Pentstemon pubescens Sol. Common in sandy soils.

Pentstemon laevigatus Sol. Rare; in drift soils about Logansport.

Veronica Anagallis L. Water Speedwell. Rare.

Castilleia coccinea Spreng. Painted Cup. About the lakes; rare.

Pedicularis lanceolata Michx. Occasionally seen in wet places.

Utricularia species. None found in flower and I have no notes on its presence in the waters of this region, although it must certainly be found. I have seen it in Carroll county on the south and in Kosciusko County to the northeast.

Tecoma radicans Juss. Trumpet Creeper. Along the railroads.

Ruellia ciliosa Pursh. In sandy soils, frequent.

Verbena angustifolia Michx. Common in the thin wind-blown, sandy soils, often barely covering the underlying limestone, west of Logansport; also occurs sparingly near the river. Not seen at the lakes.

Pycnanthemum lanceolatum Pursh. Mountain Mint. About the lakes, frequent. The bruised leaves exhale a strong odor resembling peppermint.

Pycnanthemum linifolium Pursh. Common in dry, sandy soils about the lakes. Scarcely odorous.

Calamintha Nuttallii Gray. On wet limestone ledges along the Wabash River below Logansport; here plentiful. Not seen elsewhere. Not reported in Coulter's Catalogue of the Plants of Indiana.

Scutellaria galericulata L. Scullcap. Frequent near water.

Physostegia Virginiana Benth. False Dragon Head. Frequent.

Plantago Patagonica. The only species of Plantago observed besides P. major and P. lanceolata was the above, or a variety of it. It grew near a railroad in Logansport.

Polygonum sagittatum L. Arrow-leaved Tear-thumb. Occasional in wet places.

Dirca palustris L. Leather-Wood. Common in low, moist, drift soil, woods near Logansport. I do not remember seeing it in the sandy soils at the lakes.

Comandra umbellata Nutt. Bastard Toad-flax. General in dry, sandy soils; common east of Lake Cicott.

Euphorbia dentata Michx. Abundant in one locality, at the base of a limestone bluff, west of Logansport. Not seen elswhere.

Ulmus fulva Michx. Slippery Elm, Red Elm. Is a common forest tree in drift soils, often very large.

Betula lenta L. Cherry Birch, Sweet Birch. Occurs sparingly in the támarack swamps at Delong, south of Lake Maxinkuckee.

Betula pumila L. Low Birch. Not rare about the lakes.

No notes on Carya, Quercus or Salix.

Coniferæ. The only species seen were of Larix and Juniperus; the latter is general, but nowhere abundant. *Larix Americana* Michx. occurs plentifully in the so-called tamarack swamps, and these are being limited more and more in size and number.

ORCHIDS. A careful search was made for orchids, and the following list gives all the species found:

Liparis loeselii Richard. Tway-blade. A few plants on a moist hillside south of Lake Cicott. The plants were past bloom when found, and a dried specimen was compared with those in the herbarium of Purdue University.

Spiranthes cernua Richard. Rare; in low, moist woods south of Cicott.

Godyera pubescens R. Br. Rattlesnake Plantain. Rare; in woods southeast of Cicott; plants were in leaf only.

Calopogon pulchellus R. Br. Common in swamps about the lakes.

Pogonia ophioglossoides Nutt. In a peat bog at DeLong; here common.

Habenaria bracteata R. Br. Rein-Orchis. A group of three plants found in the thin sandy woods west of Logansport.

Habenaria lacera R. Br. Ragged Fringed Orchis. Two plants found in peat bog with Pogonia.

Cypripedium pubescens Willd. Large Yellow Lady's-Slipper. Rare in the woods southeast of Cicott; not seen elsewhere.

Cypripedium spectabile Salisb. Showy Lady's-Slipper. In the low grounds on the southern extremity of Lake Maxinkuckee; rare.

Cypripedium acaule Ait. Stemless Lady's-Slipper. Common in one locality, a small, dense tamarack swamp east of Monterey.

Aletris farinosa L. Star Grass. Very rare; in low ground on the edge of a woods south of Cicott.

Allium cernuum Roth. Wild Onion. Very common in many places and in all kinds of situations. Tall and showy in the wet meadows and swamps east of Lake Cicott; less showy on moist limestone ledges on the Wabash; small and stunted in crevices of dry limestone west of Logansport.

Allium Canadense Kalm. Wild Garlic. Lake Cicott; rare.

Camassia Fraseri Torr. Wild Hyacinth. In drift soils in the valley; very rare and almost extinct.

Maianthemum Canadense Desf. About Lake Maxinkuckee, plentiful in a few comparatively dry tamarack swamps.

Lilium Philadelphicum L. Wild Orange-red Lily, Wood Lily. At the lakes; seldom seen.

Lilium Canadense L. Wild Yellow Lily. With the last and rare.

Medeola Virginiana L. Not seen.

Trillium nivale Rid. Not seen.

Tofieldia glutinosa Willd. Swamp east of Lake Cicott; rare.

Melanthium Virginicum L. Bunch Flower. With the last; rare. The swamp about one mile east of Lake Cicott, although containing only a few acres, is remarkable for the number of rare species occurring in it. Melanthium and Tofieldia were not seen elsewhere; the former is a tall plant, not readily overlooked, while the latter is quite small.

Tradescantia. The form with smooth leaves, few in number, is very common in sandy soils, especially east of Lake Cicott, and blooms early in the spring. The form with hairy leaves and blooming later is rare and was seen in drift soils only.

Peltandra undulata Raf. A few plants on edge of tamarack swamp, east of Monteray.

Scheuchzeria palustris L. In one locality only, a peat bog south of DeLong; here plentiful. Not in Coulter's Catalogue.

Potamogetons. No notes. *P. natans* is common in the Wabash River, with a narrow-leaved form resembling *P. pauciflorus.*

Naias. I do not remember seing any within the region embraced in this paper. (Have seen plants in Turkey Lake, in Kosciusko County.)

Cyperaceæ. Not being familiar with this large order, I have not given it attention; my few notes are not worth reproducing.

Panicum clandestinum L. (?) Some large plants, up to four feet in height, with stinging hair, occur in a wet meadow on the edge of a thicket near the old canal, three miles west of Logansport. The specimens taken were not in bloom, and hence the doubt about their identity.

Zizania. Water, or Wild Rice. No notes on its occurrence; absent?

Alopecuris geniculatus L. *Var. aristatulus, Torr.* A few plants found on the dirt, chiefly peat, thrown out in making a ditch through the tamarack swamp south of DeLong.

Phragmites communis Trin. A small patch occurs near the southern end of Lake Maxikuckee. Stalks 8 to 12 feet high.

Notes on Some Phanerogams New or Rare to the State. By W. S. Blatchley.

At the winter meeting of this Academy in 1889, I presented a paper entitled "Some Plants New to the State List," in which seven species were mentioned from Monroe County, and fourteen from Vigo County, as not having been previously recorded in any published list of Indiana plants. The paper was severely criticised at the time by one or two members of the Society, the species being said to be wrongly determined or to have been previously mentioned. My ardor for writing botanical papers was somewhat quenched by this criticism, but time has since proved that all identifications, with but a single exception, were correct, and no previous Indiana record for any one of the remaining twenty species has been or can be pointed out.

The paper in question was never published, and but four of the plants therein mentioned have been recorded from other portions of the State. This fact, together with the additional one that I have in my note books numerous records of plants taken within the past five years at various localities in the State, which, if published, would greatly extend the known range of such species, has led to the preparation of the present paper.

In it the stations and habitat of ninety-three species of Indiana plants are recorded, and brief notes are in many instances given regarding their abundance, variations, etc. Of these, thirty-three species, including thirteen of those mentioned in my 1889 paper, have not heretofore been recorded in print as occurring in the State; while thirty-seven have been recorded from but one other station in the State, and that in almost every instance distant from the one in which it has been collected by myself. The remaining twenty-three species have not been recorded from more than two stations in the State and they in localities widely different, as "Jefferson and Lake counties," or "Gibson and Noble counties."

Specimens of all the plants mentioned are in my private herbarium or in that of DePauw University, which, in 1893, came into possession of about 600 species of plants collected by me. Those species represented in the DePauw herbarium are marked with an asterisk in the list which follows. The date given is that upon which the species was collected, or, where collected more than once, the earliest at which it has been noticed in bloom. The nomenclature and arrangement are those of the new "Catalogue of the Pteridophyta and Spermatophyta of Northeastern North America," published in 1894 as a memoir of the Torrey Botanical Club. Where the name in the catalogue mentioned differs from that

in Gray's Manual, 6th Ed., the name used in the latter work is given in parenthesis as a synonym.

1. *Botrychium ternatum obliquum* Milde. Grape Fern.

Found in a few localities in Vigo county. Distinguished from the other forms of the species by its height, 10 to 14 inches, its more compound fruiting portion, and the oblong divisions of the sterile segment, which are very oblique at the base.

Recorded in the State Catalogue from Jefferson county.

*2. *Equisetum fluviatile* L. Swamp Horse-tail.

(*E. limosum* L.)

Found abundantly in the shallow water around the margins of the Goose Pond in Vigo county. Not given in the State Catalogue, nor in any of the published lists, but recorded in Botanical Gazette from Lake County. May 3.

*3. *Potamogeton diversifolius* Raf. Pond-weed.

(*P. hybridus* Michx.)

Frequent in a pond south of Fair Ground, Vigo county. Oct. 3, 1889. The first Indiana record.

*4. *Potamogeton spirillus* Tuckerm.

Occurs sparingly in the Five-Mile Pond, Vigo county. July 19. The first record.

5. *Zannichellia palustris* L. Horned Pond-weed.

This species grew in abundance in the pond south of the blast furnace at Terre Haute in the years 1889–93. The surface of this pond seldom froze in winter on account of the warm stream of water from the furnace flowing into it. Since the furnace shut down the pond has dried up and the plant has disappeared.

The first record for the State.

*6. *Echinodorus cordifolius* (L.) Griseb. Upright Bur-head.

(*E. rostratus* Engelm.)

Several acres of this plant grew in 1890 on the site of Conover's Pond, Vigo county, which had been drained the previous year.

The first record, its range being given in Gray's Manual, sixth edition, as "Illinois to Florida, Missouri and Texas."

7. *Panicum autumnale* Bosc. Diffuse Panicum.

Frequent in Vigo county, on sandy hillsides and banks along railways.

Recorded before by Higley and Raddin from the "sand ridges south of Whiting, Ind."

The flowers of this grass are, when in their prime, a grayish-purple in color, and, when wet with dew, reflect the morning sunlight in a peculiar and pleasing manner.

8. *Panicum minus* Muhl. Wood Panicum.

A specimen, so named by Mr. Nash, of Columbia University, N. Y., was taken from a dry hillside in Hipple's coal mine woods, Vigo county, where it is frequent.

The first record.

9. *Panicum pubescens* Lam. Hairy Panicum.

Another species named for me by Mr. Nash. It is frequent along the T. H. & L. Railway in Vigo county.

The first record.

10. *Homalocenchrus lenticularis* (Michx.) Scribn. Catch-fly Grass.

(*Leersia lenticularis* Michx.)

Taken but once, October 6, 1893, from the margin of Five-Mile Pond, Vigo county.

The first record.

*11. *Sporobolus asper* (Michx.) Kunth. Drop-seed grass.

Occurs sparingly along sandy banks and hillsides in Vigo county. August 30.

The first record.

12. *Cyperus speciosus* Vahl.

Recorded before only from Jefferson county. Taken in low, sandy soil in Vigo county, where it is scarce.

Varies much in size. A specimen taken at Heckland, October 14, 1896, had six umbels, the stalk of each apparently springing from the surface of the ground, and the whole plant but 2½ inches in height.

13. *Eleocharis capitata* (L.) R. Br. Spike Rush.

Grows along the mucky margins of the Five-Mile Pond, Vigo county. Identification verified by N. L. Britton. Recorded before in "Botanical Gazette," VII, 3, 1882, by E. J. Hill, from a slough south of Whiting, Ind., and described by him as new under the name of *E. dispar*. It is a plant of southern range, and, up to the time of Hill's record, it had not been found north of Florida and Texas, except west of the Rocky Mountains. It probably occurs in suitable localities throughout the western half of Indiana.

14. *Stenophyllus capillaris* (L.) Britton.

(*Fimbristylis capillaris* Gray.)

Occurs sparingly in Vigo county, along sandy banks and borders of fields. Recorded before from Lake county.

Grows in dense, circular tufts; the hair-like stems rarely a foot in hight.

15. *Wolffia columbiana* Karst.

Found in abundance in the Goose Pond, Vigo county, in 1890.

"Stagnant waters in the northern counties."—*State Catalogue.*

*16. *Medeola virginiana* L. Indian Cucumber Root.

Occurs on high, dry, wooded hills in Monroe county, in company with *Microstylis ophioglossoides* Nutt. and *Lycopodium complanatum* L.; scarce.

Recorded in B. & C. Flora from Jefferson and Lake counties.

17. *Habenaria flava* (L.) A. Gray. Greenish Orchis.

(*H. virescens* Spreng.)

Taken in some dense, damp woods near Heckland, Vigo county, June 10, 1891.

Recorded before from Noble county.

18. *Achroanthes unifolia* (Michx.) Raf. Adder's Tongue Orchis.

(*Microstylis ophioglossoides* Nutt.)

A single specimen was taken at Coal Creek, Vigo county, Sept. 28, 1893. In Monroe county a number of specimens were secured from high hills, where they were found in company with *Medeola virginiana* L., *Pogonia verticillata* Nutt., and in the midst of clumps of the moss *Polytrichum commune* L. Specimens taken by the writer in Arkansas were also found on high hills, though the habitat given in Gray's Manual is "low, mois ground."

19. *Leptorchis liliifolia* (L.) Kuntze. Twayblade.

(*Liparis liliifolia* Richard.)

Rare in rich woods in both Monroe and Vigo counties. June 11.

20. *Leptorchis loeselii* (L.) MacM. Twayblade.

(*Liparis loeselii* L.)

A number of specimens were taken in a tamarack swamp in Fulton county, July 14, 1894.

21. *Hexalectris aphyllus* (Nutt.) A. Gray.

Taken by the writer on a high wooded hill two miles south of Wyandotte Cave, Crawford county, July 25, 1896.

The first Indiana record, the range in both the Manual and Illustrated Flora being given as "Kentucky and Missouri to Florida and Mexico."

*22. *Polygonum arifolium* L. Halberd-leaved Tear-thumb.

Scarce in Vigo county; in ravines and along borders of small streams. Mentioned in my paper "On Plants New to the State List," read before the Academy in 1889. Since recorded from Steuben and Noble counties.

23. *Polygonum emersum* (Michx.) Britton.

(*P. muhlenbergii* Watson.)

Frequent in Vigo county along sandy margins of ponds. Noted before in Steuben and Lake counties.

*24. *Polygonum ramosissimum* Michx.

Found in low, sandy ground near a marsh south of the Fair Ground, Vigo county; scarce.

The first record.

25. *Chenopodium boscianum* Moq.

Taken in Vigo county, October 17, 1896, in open, sandy woods, two miles east of Terre Haute.

The first Indiana record.

The flowers much smaller than in allied species; on slender recurved branches; the black seeds easily separated from the enclosing pericarp.

*26. *Arenaria serpyllifolia* L. Thyme-leaved Sandwort.

Occurs sparingly in Vigo county in low, sandy soil about the margins of several of the larger ponds. Noted in the list of Higley & Raddin as being found in Lake county and by Hesslar (Proc. Ind. Acad., 1893, 259) as occurring in Fayette county.

27. *Anemone caroliniana* Walt. Carolina Anemone.

Found in Vigo county in one locality on a wooded hillside, 5½ miles north of Terre Haute. First brought to my notice in 1894 by Miss Nora Arnold, a pupil in the high school. She stated that they had occurred abundantly in the one locality for 12 or thirteen years to her knowledge, and how much longer she did not know.

The first record, the Manual range being "Illinois to Nebraska and Southward."

28. *Ranunculus obtusiusculus* Raf. Water Plantain Spearwort.

Noted in one locality, the border of a marsh near the Goose Pond, Vigo county, June 22, 1890.

Recorded from Noble county by Van Gorder under the name of *R. alismaefolius* Geyer.

29. *Ranunculus purshii* Richards.

(*R. multifidus terrestris* Gray.)

Occurs sparingly about the borders of the Five-Mile Pond, Vigo County. June 1.

The first record.

*30. *Dentaria heterophylla* Nutt. Diverse-leaved Toothwort.

Occurs sparingly in Monroe county in thickets and rich, moist woods. Recognized as a distinct species in the new Check List. Noted as such in my paper read before the Academy in 1889, though Dr. Coulter in his list of Jefferson County plants stated that it was, in his opinion, a variety of *D. laciniata* Muhl.

In Monroe county it blooms at least two weeks later, and no connecting forms were noted. Of a specimen submitted to Dr. Coulter, he wrote: "It looks very much like typical *D. heterophylla* Nutt., and is as near it as anything I have seen from the State."

The first Indiana record.

*31. *Draba caroliniana* Walt. Carolina Whitlow Grass.

Frequent in Vigo county along the banks of the old canal and on sandy hillsides near it.

One of a MSS. list of additions to State Catalogue furnished me by Dr. J. M. Coulter. Locality not given.

*32. *Descurainia pinnata* (Walt.). Britton. Tansy Mustard.

(*Disymbrium canescens* Nutt.)

Frequent in Vigo county along the gravelly banks of railways and canal. Recorded only from Tippecanoe county. April 20.

*33. *Arabis dentata* T. and G. Toothed Rock-Cress.

Rare in Vigo and Monroe counties, along gravelly banks or rocky hillsides. Recorded before from Gibson county. May 3, 1891.

34. *Arabis hirsuta* (L.) Scop. Hairy Rock Cress.

Found by the writer in Monroe, Montgomery and Vigo counties. Grows along rocky hillsides.

Recorded by Van Gorder as being scarce in Noble county.

35. *Sedum telephioides* Michx.

Collected along the hillsides at Coal Creek, Vigo county, by Dr. B. W. Evermann in 1889. April 30. The State Catalogue record is "Knobs," Clark county.

*36. *Parnassia caroliniana* Michx. Grass of Parnassus.

This species was recorded by Stanley Coulter, Proc. Ind. Acad. Sci., 1894, 105, as being found in Noble and Kosciusko counties, the latter record being based on a specimen collected by the writer, now in DePauw herbarium. It has since been noted by myself at Lake Maxinkuckee, Marshall county, and in a marsh on the banks of White River one mile south of Broad Ripple, Marion county.

37. *Opulaster opulifolius* (L.) Kuntze. Nine-Bark.

(*Physocarpa opulifolia* Raf.)

Recorded in the State list from Gibson, Jefferson and Monroe counties.

This handsome flowering shrub has been noted by the writer as growing plentifully on the banks of White River below Broad Ripple, Marion county, and on the banks of the Wabash just south of the city of Wabash, Wabash county. It has also been recorded from Wayne and Lake counties, so that its range undoubtedly includes the whole State.

*38. *Geum macrophyllum* Willd.

Taken in the borders of rich open woods two miles east of Terre Haute, Vigo county, June 26, 1892.

The first Indiana record.

*39. *Sanguisorba canadensis* L. Canadian Burnet.

(*Poterium canadense* Benth. and Hook.)

Occurs along the borders of ditches and damp virgin prairies near Heckland, Vigo county. In flower from August 10 to October 20.

The first Indiana record, the range of Manual being "Newf. to mountains of Georgia, west to Michigan."

40. *Trifolium reflexum* L. Buffalo Clover.

Rare in Vigo county, along open sandy hillsides and borders of prairies. Heretofore noted from Marion county. May 28.

41. *Amorpha fruticosa* L. False Indigo. River Locust.

Frequent along the bed and sides of the old canal both north and south of Terre Haute, and as far north as Montezuma, Parke county.

Recorded from Gibson.

42. *Falcata pitcheri* (T. & G.) Kuntze. Large-leaved Hog Peanut.

(*Amphicarpæa pitcheri* T. & G.)

Found sparingly along damp hillside thickets in Vigo county.

The first Indiana record.

Leaflets much larger than in *F. comosa* L., the blade often more than 3 inches long; pods—ten or more—1½ inches long, borne on a long, hairy rachis; seeds, 5 mm. in length.

*43. *Polygala polygama* Walt. **Pink Polygala.**

Vigo county, in small numbers, along the Vandalia Railway, one mile east of Terre Haute.

Recorded before from Lake and St. Joseph counties.

44. *Euphorbia heterophylla* L.

Occurs in Vigo county, along the banks of old canal near Five-Mile Pond.

The first Indiana record.

The pods of this and allied species, when dry, burst open with a snapping or crackling noise, and project the seeds to a distance of several feet.

45. *Callitriche heterophylla* Pursh. Water Starwort.

Vigo county, in ponds; frequent. April 30.

Recorded from Gibson county.

46. *Rhus aromatica* Ait. Fragrant Sumach.

(*Rhus canadensis* Marsh.)

Recorded in the State list from Jefferson and Lake, the two extremes of the State. Taken by the writer in Monroe and Crawford counties. Grows on rocky hillsides along streams.

47. *Rhamnus caroliniana* Walt. Carolina Buckthorn.

A shrub or small tree of southern range which occurs as far north as Crawford and Harrison counties, Indiana, where it was first noted by the writer November 5, 1896. Straggling in habit; 10 to 20 feet high, with peach-like leaves, glossy green above; bark smooth and light colored; the wood bright yellow; fruit, a black drupe resembling a cherry. Hillsides along Blue River near Wyandotte cave, and roadsides between there and Corydon; scarce. The first Indiana record, the Manual range being "N. J., Va. to Ky. and southwest."

48. *Hibiscus lasiocarpus* Cav.

Grows in prairie swamp near Heckland, Vigo county.

Recorded before from Gibson.

*49. *Hibiscus militaris* Cav. Halberd-leaved Rose Mallow.

Frequent along the sandy banks of old canal between Ft. Harrison, Vigo county, and Montezuma, Parke county. "Knobs," and Jefferson county are the two previous records. July 10.

*50. *Hypericum ascyron* L. Great St. Johnswort.

Banks of larger streams in Monroe and Putnam counties; scarce. Mentioned in my 1889 paper. Since recorded from Noble county by Van Gorder.

51. *Hypericum densiflorum* Pursh.

Found on edge of river bank in woods just below Ft. Harrison, Vigo county, Oct. 12, 1896.

The first record for Indiana; the Manual range being "Pine barrens of N. J. to glades of Ky., Ark. and southward."

52. *Helianthemum canadense* (L.) Michx. Frost-weed; Rock-rose.

Vigo county, on a sandy hillside near Five-Mile Pond; frequent locally. May 28.

Recorded from the sand hills of Lake county; also from Noble.

*53. *Viola lanceolata* L. Lance-leaved Violet.

Margins of Goose Pond and moist prairies at Heckland, Vigo county. April 16.

The previous records are Lake and Jefferson counties.

*54. *Rotala ramosior* (L.) Kœhne.

Vigo county, in ditches and along margins of ponds; scarce.

Jefferson and Clark counties are its previous records.

*55. *Ammannia coccinea* Rottb. Ammannia.

(*Ammannia latifolia* L. Gray's Manual, 5th ed.)

Noted in both Vigo and Monroe counties; scarce in the latter. Aug. 10 to Oct. 20.

Recorded from Gibson.

56. *Decodon verticillatus* (L.) Ell. Swamp Loosestrife.

(*Nesæa verticillata* HBK.)

Occurs rarely in Monroe, Vigo and Marshall counties.

Recorded in State Catalogue from "Gibson and Posey. Rare." Recorded since from Noble and Steuben. It therefore probably occurs in suitable localities throughout the State.

57. *Œnothera sinuata* L.

Vigo county, about the borders of a sandy cultivated field near Ft. Harrison; scarce. May 14, 1891.

Probably a railroad migrant from the South, the Manual range being "N. J. to Fla., west to E. Kansas and Texas."

The first Indiana record.

58. *Myriophyllum verticillatum* L. Water Milfoil.

Ponds of Vigo County; scarce. May 2.

Mentioned without note in the Steuben County Flora.

59. *Eulophus americanus* Nutt.

Borders of damp prairie, near Heckland, Vigo County; scarce. October 5, 1889.

Recorded from Gibson County.

*60. *Cornus circinata* L'Her. Round-leaved Dogwood.

Borders of open, moist woods four miles southeast of Terre Haute; scarce. May 8.

Recorded from Lake County.

61. *Hypopitys hypopitys* (L.) Small. Pine-sap. False Beech-Drops.

Found on high, dry wooded hillsides in both Monroe and Vigo counties; rare. A specimen taken in Monroe, June 30, 1886, had the raceme 21 flowered.

Recorded from Jefferson and Noble counties.

*62. *Gentiana andrewsii albiflora* Britton. White Gentian.

(*Gentiana alba* Muhl.)

Grows in one locality in Vigo county, a wooded hillside north of Terre Haute near the Five-Mile Pond; scarce. September 23, 1888.

Tippecanoe and Noble counties are its other State records.

*63. *Gentiana saponaria* L. Soapwort Gentian.

Vigo county along the borders of prairies; scarce. September 15.

Its previous State record is Lake county.

*64. *Obolaria virginica* L.

Collected on several occasions in both Monroe and Vigo counties, but rare in each. Three plants, taken in doors by Prof. Evermann on January 26, bloomed on February 11.

Its other State record is Clifty Falls, Jefferson county.

*65. *Phlox bifida* Beck. Dwarf Phlox.

In the State Catalogue this species is said to be "common in Tippecanoe." It has been taken by me in both Vigo and Monroe counties; in the former being very common on the sandy hillsides north of Terre Haute. April 7.

66. *Hydrophyllum canadense* L. Canada Waterleaf.

Noted heretofore from Jefferson and Laporte counties. It occurs also sparingly on the sides of deep wooded ravines in both Monroe and Vigo counties.

*67. *Macrocalyx nyctelea* (L.) Kuntze. Ellisia.

(*Ellisia nyctelea* L.)

Rare in Vigo county, having been taken but once from a damp spot in sandy open woods, two miles east of Terre Haute. May 25.

The first Indiana record.

68. *Cunila organoides* (L.) Britton. Common Dittany.

(*Cunila mariana* L.)

Occurs frequently on the summits of dry rocky hills in Monroe county. June 20.

Recorded in the State Catalogue from the "Knobs."

69. *Synandra hispidula* (Michx.) Britton. Large-flowered Mint.

(*Synandra grandiflora* Nutt.)

Taken by the writer in Monroe, Putnam, Vigo and as far north as Wabash county, though its range is given in the Barnes & Coulter Flora as "Banks of the Ohio and its tributaries." May 25.

*70. *Stachys cordata* Riddell. Heart-leaved Hedge Nettle.

Borders of damp upland thickets in Vigo county; scarce.

"Jefferson and Gibson" are its previous records.

71. *Trichostema dichotomum* L. Blue Curls. Bastard Pennyroyal.

Discovered by Professor Evermann, September 1, 1889, in sandy soil on the banks of the Wabash River south of Terre Haute, Vigo county.

A species of southern range, probably introduced in the past by the commerce of the river.

Its first Indiana record.

72. *Gratiola sphærocarpa* Ell. Hedge Hyssop.

Taken in both Monroe and Vigo counties; scarce. April 30.

In the State Catalogue recorded from "Barrens of Southern Indiana."

*73. *Wulfenia houghtoniana* (Benth.) Greene.

(*Synthyris houghtoniana* Benth.)

Found in one locality on sandy hillside one-half mile southeast of Five-Mile Pond, Vigo county, where it was uncommon.

"Tippecanoe and northward" is the only previous record.

74. *Afzelia macrophylla* (Nutt.) Kuntze. Mullein Foxglove.

(*Seymeria macrophylla* Nutt.)

On dry hillsides in Montgomery, Putnam and Vigo.

"Near the Ohio and Wabash" was recorded in the Barnes and Coulter Flora.

75. *Orobanche ludoviciana* Nutt. Broom-rape.

(*Aphyllon ludovicianum* Gray.)

Banks of Wabash River near brick yards above Terre Haute, Vigo county; frequent locally. Parasitic on the roots of the Great Horse-weed, *Ambrosia trifida* L. Discovered by Prof. Evermann October 2, 1889.

The first Indiana record, its Manual range being "Minnesota to Illinois and Texas."

76. *Plantago aristata* Michx.

(*Plantago patagonica aristata* Gray.)

Evansville & Terre Haute Railway and canal banks south of Terre Haute, Vigo county; scarce. June 24, 1888.

The first record for the State.

77. *Viburnum molle* Michx.

Found along the fence-rows and margins of dry upland prairies below Youngstown, Vigo county; scarce.

The leaves larger, more rounded, thicker and more soft and downy than those of *V. dentatum* L.

Recorded from Jefferson county.

77*a*. *Willoughbya scandens* (L.) Kuntze. Climbing Hemp-weed.

(*Mikania scandens* L.)

A handsome twining member of the Compositae.

Found in abundance covering the shrubs growing south of the wagon bridge across Sandy Hook creek, five miles east of Hebron, Porter county, September 21, 1897.

Recorded before from Gibson county by Dr. Schneck. Manual range, "E. New Eng. to Ky. and southward."

78. *Lacinaria spicata* (L.) Kuntze.

(*Liatris spicata* Willd.)

Virgin prairies near Heckland, Vigo county; scarce. Aug. 17.

Recorded from Jefferson and Lake.

*79. *Chrysopsis villosa* (Pursh) Nutt. Golden Aster.

Along the sandy banks of the old canal between Ft. Harrison and Five-Mile Pond, Vigo county.

The first record for the State, its range being given as "Wisconsin to Kentucky and westward."

80. *Solidago odora* Ait. Sweet Golden-rod.

Near Heckland, Vigo county, from borders of prairies; rare. Sept. 15.

Recorded before only from Gibson county, by Dr. Schneck, who, according to State Catalogue, "was inclined to doubt this species." Dr. J. M. Coulter, to whom my specimen was sent for verification, noted it as "a good find," so that it must be rare in the State. It is regarded as a valid species by the authors of the Catalogue of the Flora of Northeastern North America.

*81. *Solidago rigidiuscula* (T. & G.) Porter.

(*Solidago speciosa angustata* T. & G.)

Clearings and borders of prairie at Heckland, Vigo county. Sept. 5.

The first Indiana record.

*82. *Solidago serotina* Ait.

In woods along the borders of the Wabash River below Ft. Harrison, Vigo county; frequent locally.

Recorded from Jefferson county. Sept. 8.

*83. *Solidago speciosa* Nutt.

One of the most handsome of the Golden-rods. Grows plentifully in the prairie at Heckland, Vigo county. Aug. 25.

The first Indiana record.

84. *Euthamia caroliniana* (L.) Greene. Slender-leaved Golden-rod.

(*Solidago tenuifolia* Pursh.)

Frequent in Vigo and Monroe counties; along shaded banks, usually in sandy soil. Aug. 21.

Noted before from Jasper county.

85. *Sericocarpus linifolius* (L.) B. S. P.

(*Sericocarpus solidagineus* Nees.)

Borders of prairies at Heckland, Vigo county, where it is scarce.

Recorded from Floyd county in B. & C. Flora.

*86. *Aster drummondii* Lindl. Drummond's Aster.

Low open pastures and prairies; frequent in Vigo county. The first record for the State, its range being given by Gray as "Illinois to Minnesota and Kansas."

*87. *Aster ericoides* L. Heath-like Aster.

Fence rows and old fields, in open, dry soil. Common in Monroe, scarce in Vigo county.

Recorded in B. & C. Flora only from Jefferson.

88. *Aster linariifolius* L. Double Bristled Aster.

On dry, sandy hillside near Five-Mile Pond, Vigo county; scarce. Also near Miller's, Lake county.

Recorded in the State Catalogue from the "Knobs" under the name of *Diplopappus linariifolius* Hook.

Readily known by the shortness of the stems, which grow in clumps, and by the rigid linear leaves. Heads large and showy.

89. *Ambrosia bidentata* Michx. Two-toothed Ragweed.

Roadsides and borders of cultivated fields between Glen, Vigo county, and Staunton, Clay county; common locally. First noted August 23, 1895. The first record for the State, its Manual range being "Prairies of Illinois, Missouri and Southward."

90. *Bidens trichosperma* (Michx.) Britton. Tickseed Sunflower.

(*Coreopsis trichosperma* Michx.)

Occurs sparingly in Monroe county in swamps along the bottom lands of Bean Blossom Creek. August 10, 1886.

Recorded in B. & C. Flora from Jefferson county.

91. *Hymenopappus caroliniensis* (Lam.) Porter.

(*H. scabiosæus* L'Her.)

Found sparingly on the side of a sandy ridge northeast of Seventh Street Bridge across Lost Creek, Vigo county. May 31, 1890.

The first record for the State, its range being given in the Manual as "Illinois and Southward."

92. *Senecio lobatus* Pers. Butterweed.

Taken on several occasions in 1891 and 1892 from low, damp places about ponds and ditches in Vigo county. The first Indiana record, its Manual range being "North Carolina to Southern Illinois, Missouri and Southward."

93. *Lactuca hirsuta* Muhl. Hairy Wild Lettuce.

(*Lactuca sanguinea* T. & G.)

Borders of prairies and dry, sandy fields in Vigo county; scarce. Recorded from Gibson county by Dr. Schneck.

Periodicity of Root Pressure. By M. B. Thomas.

The fact that the roots of plants absorb water and force it up through the stem, producing bleeding whenever the stem is injured, was discovered by Hales in 1721, and since that time numerous investigators have examined this phenomenon of root absorption in a more or less exhaustive way until we have to concern ourselves only with an inquiry into its daily variations and see if there is not some law governing the changing phenomenon that will give us a more complete insight into this important physiological problem in plant growth.

The general matter of the periodicity of root pressure in forcing water through stems in opposition to gravity was studied by Sachs, and his observations form a basis for our present work. He made experiments regarding the time of maximum and minimum pressure with a few common plants, and his results are too well known to need extended description. The conclusions of his experiments have been to fix the time of maximum pressure at 9–11 A. M., with a decrease

through the P. M. and early night, when a minimum was reached. After this the pressure increased until it attained the maximum during the following A. M. Sachs further showed that the periods of maximum and minimum pressure were independent of small variations in temperature.

The work of Sachs was done by the use of crude instruments that required constant attention, and it seemed that an instrument of precision, making automatic records, would enable one to add something to the work already done on the subject of root pressure. In 1890 a rude instrument was made of wood and iron, and some few experiments conducted on the subject. Later a machine of more accurate working was constructed at the college workshop in Crawfordsville, and this formed a pattern for the one made at Lafayette under the supervision of Dr. Arthur. In the evolution of the apparatus to its present condition changes have been introduced that brings the machine into a form easily used by the average student and capable of giving accurate results.

For our work on the subject of root pressure many plants were grown from seeds in the greenhouse, and were used when the stems were 4–5 mm. in diameter. With those plants secured from out of doors or at other green houses, they were brought in weeks before the experiments and given ample time to adjust themselves to any changes in their surroundings. The results show that the latter plants corresponded in their records with those grown in the green house from seeds. For the experiments the attachment of the plant to the machine was made in the usual way under water, and the apparatus placed on an iron pier to prevent jarring. The records of temperature were made by a self-recording thermometer. The clock used in the root pressure machine would run for eight days, and an experiment when properly started needed no attention until its completion, or until the time when the pressure was insufficient to show itself on the rods of the instrument. The increasing weight of the column of mercury usually produced this result in 4–5 days. The smoked rods with the record of the periodicity were placed on sensitive paper, and the lines printed for permanent preservation. Temperature cards were preserved along with these for comparison. The plants experimented upon were fuchsia, bean, geranium, grape, sunflower, tomato, etc.

Occasionally upon the attachment of the plant a decided negative pressure in the stem would be observed. This was especially noted in the grapevine growing out of doors, where the records were made. The negative pressure was so great that the water and part of the mercury were pulled down into the stem and the particles of mercury could be found in the ducts upon splitting the twigs an inch or more from the top, where the attachment was made. This phenomenon was

observed by Sachs, and is, no doubt, due to the fact that where active transpiration is going on no root pressure exists, but transpiration or other current do not permit the ducts to become filled with water, but, rather, they contain rarified air that allows the water poured in on top of the cut surface to be drawn down in the stem.

A study of the records warrant the following general statements regarding the relation between temperature and root pressure: Under usual conditions there can be no relation between the periodicity of root pressure and the daily variations in temperature, the latter being between 50° F. and 90° F., as determined in the course of the experiments. Even where the periods of maximum and minimum temperature were reversed in the test, and the reversed condition continued for several successive days, no appreciable effect was noticed in the periodicity of root pressure.

The changes in temperature above or below certain limits may alter the regularity of the times of maximum and minimum pressure periodicity, but do not interfere with the main cycles of greater or less pressure.

The time element is the all important one, and for most plants the period of maximum pressure is 12 M., with the limits between 9 A. M. and 1 P. M.

No appreciable difference exists between the times of maximum pressure in the variety of plants studied and certainly none whatever in a large number of specimens of the same species even though they may have been grown under different conditions.

The age of the plant seems to make no difference in the times of maximum and minimum periodicity or its general behavior in the experiment, except, as would be expected, a large and vigorous plant shows more difference between the amount of maximum and minimum pressure than a small and less vigorous one.

In different genera marked differences exist as to the maximum amount of root pressure and in some it is so small that at no time can it be measured except with great difficulty.

The amount of water present in the soil within certain limits does not affect the time of periodicity or amount discharged, but in very dry soil, where the roots become wilted, changes are evident as the result of the loss of the turgidity of the root.

A consideration of the relation between root pressure and the other phenomena in living plants will be interesting in this connection. With regard to its relation to transpiration, the latter can not be explained by the former, since, at the most, it is not sufficient to lift the water above 80–90 feet. Root pressure furnishes only a part of the water used in transpiration, as was shown by our own

and previous experiments,[1] and no root pressure was found in plants during rapid transpiration. The time of greatest transpiration seems to bear no relation to the time of greatest or least root pressure, and changes in temperature that affect the former do not influence the latter to any degree.

Where no transpiration is going on the root pressure may produce sufficient pressure in the plants of medium height to force the water out through the water pores of the leaves, or in some cases producing blistering in the tissues of the stem, as in the well-known case of the Oedema of the tomato.[2]

The relation of the root pressure with growth does not warrant any statement as to the influence of one upon the other. The time of either the maximum or minimum periods of each do not correspond, and changes in temperature that affect growth produce no changes in the constancy of the root pressure.

Studies regarding the relation between root pressure and assimilation show all negative results, and the changes producing variations in the latter have no effect on the former. The same may be said of the relation between root pressure and respiration.

In view of these facts we are warranted in the following general conclusions.

The periodicity of root pressure seems to be inherent in the plant, and has either been acquired by previous adaptation to environments, or as the results of the action of some constant or periodic changes in the plant. As with the periodicity of growth and other periodic phenomena it does not always follow that a periodic change has not been produced by some constantly or continuously acting agent.

Root pressure does not seem to have any relation to the previous periodicities of the vital activities of the plant when the top was connected with the roots.

The measure of the root pressure seems to be the osmotic activity of the root hairs, and is probably due to the presence of organic acids and other substances in the rhizoids that show great affinity for water.[3]

Although the organic acids increase in the cells at 50°–60° F., yet their increase does not seem to make any appreciable difference in the periodicity. This is true even when the temperature of the soil is brought up to 55° F., approaching the time of minimum pressure.

The fact that seems inexplicable is that, when the temperature is raised above the point where the organic acids decompose (60° F.) [4]in most plants, the roots may show an increase in their osmotic activity at the daily period of maximum

[1]DeVries, Arb. Les. Bot. Inst. (B. I , p. 228).
[2]Atkinson, G. F., Bull. Cornell Exp. Station, No. 83, 1893.
[3]DeVries, Bot. Zeitung, 1877, S. 1-10.
[4]DeVries, Bot. Zeitung, 1883, S. 850.

pressure. The absence of a top to the plant, and its consequent loss of periods of maximum and minimum oxidation, which are the real causes of the variation in the quantity of organic acids in the cell,[5] [6] may be the reason for the failure to produce the expected results. The time of periodicity of root pressure is constant in the same genus, but some species may show greater absolute pressure than others. This may be due to accidents in growth, etc. The fact of the periodicity of root pressure seems to be established beyond the possibility of a doubt, and capillarity and similar phenomena, as suggested by Prof. C. B. Clark[7] and others, can not account for the facts observed.

Notes on the Flora of the Lake Region of Northeastern Indiana.

By W. W. Chipman.

A glance at any map of Indiana showing the lakes and marshes will convince one of their special abundance in the north part of the State; and many more will be observed in the northeastern counties than in the northwestern.

In the Fifteenth Report of the State Geologist of Indiana[1], Dr. John M. Coulter divides the State into seven botanical regions, one of which he calls the "Lake Region." Included in this "Lake Region" are the sixteen northernmost counties of the State, with the exception of the very northwestern counties, Lake and Porter.

I would separate from his Lake Region some of the most northeastern counties, and claim for this territory sufficient peculiar conditions for plant growth to merit its being considered a distinct botanical region, and would call it "The Lake Region of Northeastern Indiana."

OUTLINE OF THE REGION.

A line drawn from the vicinity of Warsaw, Kosciusko County, north along the line of the C., C., C. & St. L. R. R. to its intersection with the northern boundary of the county, and from thence northeast through LaGrange, LaGrange County, to the northern boundary of the State; and a line drawn from the vicinity of Warsaw east along the line of the P., Ft. W. & C. R. R. to its intersection

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[5] Ward, Proceedings of Royal Soc., Vol. XLVII, pp. 393–443.
[6] Warbung, Untersuchungen, etc., pp. 77–92.
[7] Linnean Soc. Journal.
[1] 15th Rep. State Geologist Ind., p. 256.

with the eastern boundary of the county, and from thence northeast through Waterloo, DeKalb County, to the eastern boundary of the State, would enclose approximately this Lake Region of Northeastern Indiana.

I would not attempt to bound it by any invariable line. The characteristic conditions for plant growth found in the center of the region may at some places extend somewhat beyond the limits given, and at other places may not reach them.

The region includes, in general, all of Steuben County and Noble County, the northeast part of Kosciusko County, the southeast part of LaGrange County, and the extreme north part of Whitley County.

This part of the State has for some time appeared to me to present conditions for plant growth different even from the rest of the northern counties contained in Dr. Coulter's "Lake Region," and I am glad to have it proven by Dr. Dryer in his geological report of Steuben County[2] that this region as outlined above has separate and distinct geological features. After speaking of the drift left by the Saginaw ice and the Erie ice, and the confused mass of drift left by their union, he says[3]: "Such a belt or drift forms the Saginaw-Erie interlobate moraine, which in Indiana stretches across the counties of Steuben, LaGrange, Noble, Whitley and Kosciusko. Thus are the peculiarities of topography and soil in that region accounted for."

It is not claimed that plants characteristic of the region are not found in the neighborhood of lakes of northern Indiana outside of its limits.

The proportion of lakes and their characteristic surroundings *outside* of the Northeastern Indiana Lake Region, is so small when compared with such condiions *in* the region, that plants found *farthest from the lakes*, together with *others entirely foreign* will *predominate* in the *other northern* counties.

In a report in 1874, by G. M. Levette[4], upon the geology of the northern tier of counties, including a greater part of the region under discussion and the most northern counties of Dr. Coulter's Lake Region, he says[5]: "On the eastern side of the district, the land originally timbered is largely in excess of prairies and openings, but, as we go west the proportion of prairie land increases." In the same report he says of Elkhart County[6]: "Only a small per cent. is covered with peat-bogs, lakes and marshes." Of St. Joseph County he says[7]: "Diversified with prairies, oak, openings, and rolling timber lands;" and[7], "small tracts

[2] 17th Rep. State Geologist Ind., 1891.

[3] Idem, p. 132.

[4] 5th Rep. State Geologist, Ind., 1874.

[5] Idem, p. 432.

[6] Idem, p. 452.

[7] Idem, p. 457.

of low, marshy ground." Of LaPorte County[8]: "The central and southern parts are mostly prairie;" and only[8], "small marshy spots and peat-bogs" to the north. Marshall County is spoken of in another report by W. H. Thompson[9] as mostly prairie and large tracts of barren land.

These references to *small* percentage of lakes, swamps and bogs from these northern counties not in the lake region under discussion, when compared with the continued references, everywhere, to the *large* percentage of such conditions in the northeast Indiana lake region, would seem to be sufficient authority for separating it from the "lake region," as formerly considered.

OUTLINE OF THE BOTANICAL WORK DONE IN THE REGION.

A Flora of Steuben County was published in 1892 by E Bradner[10], and a Flora of Noble County in 1893 by W. B. Van Gorder[11]. So far as I can ascertain, no geological report has ever been made for Kosciusko County, and no specimens of plants preserved, other than those in my herbarium.

In company with Prof. A. B. Crowe, of Ft. Wayne, and Thomas A. Davis, of Goshen, I made a short collecting trip through the lakes and marshes in the northeastern part of Kosciusko County, during the last of June and the first of July, 1894; and I have made collections in the more immediate vicinity of Warsaw since 1893.

During the summer of 1896 I spent several weeks in the study of the grasses and sedges of the immediate vicinity of Warsaw, under Dr. Stanley Coulter, but owing to rains and floods making it impossible to get to desirable low regions, and to the fact that I was limited to a part of each day by other work, I was able to collect and study but some forty species.

I may say that it is at the suggestson of Dr. Coulter that I attempt this paper.

The Floras of the two counties mentioned, and my own collections will be referred to as a basis for deductions, since the three counties thus covered will comprise the greater part of the region, and no reports of the botony of the other counties—only small parts of which are included in the region—have been made.

GENERAL PHYSIOGRAPHIC CONDITIONS.

The climate throughout the region is the same; there being only about forty miles difference in latitude and sixty miles in longitude. The general surface of the country is rolling, and almost hilly to the north, sloping in general to the

[8]Idem, p. 462.
[9]15th Rep. State Geologist Ind., p. 178.
[10],7th Rep. State Geologist Ind., 1891-2, p. 125.
[11]18th Rep. State Geologist Ind , 1893, p. 33.

southwest. About one-third of the region was originally covered with heavy timber, and the soil of this part is a clayey loam. The soil of the very small areas of prairie land is a sandy loam, and the swamps are filled with rich, black muck and peat many feet deep. This is the general distribution, but pure sand and clay are often found by themselves, over more or less extensive areas. Occasionally sand and muck are found in combination.

These different soils furnish sustenance for a flora of a widely varied species, while those thriving best in wet soil or growing in water will predominate.

LOCAL PHYSIOGRAPHIC CONDITIONS.

In the northern part of Steuben County, to the extreme northeast of the region, are localities of pure sand of rather extensive area, and lakes entirely surrounded by sand and lime deposits, around whose edges, and in whose bottoms, *scarcely any* vegetation is to be found. Sandy spots devoid of vegetation are occasionally found throughout the region, but of very limited extent. The Steuben County tracts are quite peculiar to their immediate vicinity, and perhaps should not be included. In none of the other counties do we find entire lakes so destitute of vegetation. I have counted over ten plants in Bradner's list[12] characteristic of a barren soil which are not found so far, or only occasionally, in the rest of the region. In general, there would seem to be the greatest prevalence of plants characteristic of lighter sandy soil in Steuben County, the greatest prevalence of plants indicative of a wet, peaty soil in Kosciusko County, and rather more of a mixture of the two in Noble County, between. But a very general uniformity of species will be found throughout the region, which will increase with closer study and more extended collecting.

PHYSIOGRAPHIC CHANGES.

1. *Low Swamps.* The lakes are for the most part surrounded by low lands or marshes, which show that the lakes were once of much greater extent. Soil is accumulating around these lakes by the growth and decay, from season to season, of the rank vegetation around the edges, and this process is continually diminishing the size of the lakes, forming large marshes, which are being drained by ditching and tiling. A great deal of valuable land has thus been reclaimed and successfully farmed.

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[12] 17th Rep. State Geologist Ind., 1891-2, p. 135.

The result of this change is a decreasing area for water plants, but an increasing area for swamp plants, which area is again converted into cultivated dry land. While this is a slow process, and has not materially decreased the size of the lakes very lately, yet a great deal of swamp land which formerly was overflowed at periods of high water has been, within the past twenty years, so successfully drained as to make dry, tillable land. The amount of swamp land in Kosciusko County at present is not one-half what it was twenty years ago; but there was so much land of this character then, that the remainder, with the lakes added, is sufficient to designate this as a true lake region.

The same changes have taken place to a greater or less extent in all the other counties of the region.

But few species have, in all probability, been yet lost to this flora by these changes, but the abundance of many species must be greatly reduced.

By means of this system of drainage the land passes from the wettest swamp through all gradations to dry, solid land, and the plants growing on it change in a like manner.

I have in mind a certain swamp, which was an outlot of the city of Warsaw, Kosciusko County, in which grew, fifteen or sixteen years ago, great quantities of *Typha latifolia* L., *Sagittaria variabilis* Englem., *Cypeous strigosus* L., and such plants as grow in the wettest swamps. Open ditches were put through and the soil was gradually dried. These plants gradually disappeared, and such plants as *Lobelia syphilitica* L., *Lobelia cardinalis* L., *Lysimachia stricta* Ait., *Iris versicolor* L., and *Potentilla fruticosa* L., were noticed. As the ground further dried out, and these began to disappear, others were observed, such as *Parnassia Caroliniana* Michx., *Viola palmita* L., *var cucullata* Gray, *Viola Canadensis* L., and *Gerardia purpurea* L. Even these finally disappeared, until one can now only occasionally find a plant of *Viola palmata* L., *var cucullata* Gray, and such weeds as grow in a pasture lot—thistles, burdock, etc.

This land has, under my observation, undergone these complete transformations as regards its soil and plant life, and is only an example of numerous similar instances throughout the entire region.

The rich black muck soil thus formed and mixed with some sand and lime (which latter shows itself in places in marl deposits) produces plants of exceptional size, shows many specimens of rapid growth and unusual development, and affords much material for study along that line.

This reclaimed soil has proven specially adapted to the growth of celery, and Warsaw is becoming a large shipping point for celery of exceptionally fine quality.

2. *Tamarack Swamps.* Much of this peat or muck land was formerly covered with tamarack, *Larix Americana* Michx. The trees grew very near to one another and formed a very dense forest, often with an undergrowth of *Rhus venenata* DC., and *Betula pumila* L.

The tamarack has for the most part been cut down, and where standing, the trees are often dead. The drying of the soil takes away one essential condition to their growth.

In and near a few tamarack swamps still standing I collected the only specimens of *Betula pumila* L., I have seen in Kosciusko County. It is not reported from Noble County by Van Gorder[13], but is from Steuben County, by Bradner[14], so that it is probably found sparingly throughout the region and disappearing with the tamaracks.

About ten years ago I collected one specimen of *Cypripedium acaule* Ait., in the edge of a tamarack swamp in the vicinity of Warsaw, Kosciusko County.

In 1882 Dr. Coulter[15] lists it as found in a tamarack swamp in Noble County. Mr. Van Gorder gives reference to the "Editors of the Botanical Gazette, 1881," as his authority for listing it in his Noble County Flora[13*]. It is not reported from Steuben County by Mr. Bradner[14], and has not been seen in Kosciusko County since the specimen mentioned. The authors of the Lake County list[16] claim *that* as the *only* Indiana station, and mark it "local." The specimen has evidently been lost to this flora by absence of proper conditions for growth.

In connection with the decadence of tamarack swamps in this region, it has been observed that a great many of the plants listed by Dr. Jno. Coulter[17] as being characteristic plants of his "Lake Region" are not at present the characteristic plants of the "Lake Region of Northeastern Indiana." Of his list of twenty plants, *Betula pumila* L., *Tofieldia glutinosa* Willd., *Lilium superbum* L., *Ruellia ciliosa* Pursh., *Solidago stricta* Ait., *Ribes rubrum* L., *Potentilla argentea* L., and *Myriaphyllum spicatum* L, are very rarely found; while *Cypripedium acaule* Ait., *Oxalis acetasella* L., *Aster longifolius* Lam., and *Vaccinium Pennsylvanicum* Lam., have not been reported since that time. *Arabis lyrata* L., and *Lechea major* Michx., are only occasionally found. *Elodes campanulata* Pursh.,

[13] 18th Rep. State Geologist Ind., 1893, p. 33.

[14] 17th Rep. State Geologist Ind., 1891-92, p. 135.

[15] Bot. Gazette, V. Sup. I., 1882, Flora of Indiana.

[16] Higby, Wm. K., and Raddin, Chas. S., Flora of Cook Co., Ill., and a part of Lake Co., Ind. Bull Chicago Acad. Sci. II.

[17] 15th Rep. State Geologist Ind., p. 259.

*Mr. Van Gorder recently reports it personally found in Noble County, but it is by no means common.

Maianthemum Canadense Desf., and *Allium cernuum* Roth., are found more commonly, but not in such abundance as to be termed characteristic of the region. This only leaves two plants of the list which now remain as characteristic, viz.: *Lobelia Kalmii* L., and *Scutellaria galericulata* L.

It is true, of course, that Dr. Coulter's "Lake Region" covered more territory than the "Lake Region of Northeastern Indiana," but this latter was included, and formed a very considerable part of it, and the fact that only two of his list can now be called characteristic of our smaller Lake Region has its significance.

It must be that the entire north part of the State has undergone a noticeable change in conditions producing its characteristic plants, or that this northeastern part under consideration has alone changed, or that we have here conditions different from the remainder of the former Lake Region which were existent at that time. Most of Dr. Coulter's observations were along the line of the L. S. & M. S. R. R.—largely in St. Joseph County—and only touching our region in Noble County.

It is quite probable that the observations at that time did not extend so thoroughly in our region as in the districts to the north and west, where there was not such an abundance of lakes and pure lake forms.

The tamarack and associated swamp plants are more frequent in Dr. Coulter's list than our present lake plants and swamp plants free from tamarack surroundings. Our most common species of this latter class, now so abundant, can scarcely be of very recent introduction, and this would seem to show that our pure lake plants were not even then (1886) so abundant in the remainder of Coulter's Lake Region as in this part of it which we call the Lake Region of Northeastern Indiana, proving more conclusively the distinctiveness of this region. The gradual disappearance of the tamarack is no doubt general throughout northern Indiana, and the list referred to would not include so many characteristic plants for *any* northern county as when made, yet it would seem evident that the list never contained as many plants peculiar to our region as to the counties north and west of us, and that there always have been more pure lake forms in the counties included in the Northeastern Indiana Lake Region than in the remainder of northern Indiana. From the frequent references which will occur to Lake County as the only other station, or one of a few other stations, for a number of the plants peculiar to the Northeastern Indiana lake region, it may be inferred that Lake County as a whole is very similar to this region, and, with the intervening territory, should be included. When the lists of this region and the lists of Lake County are compared it will be found that there are many plants not in common.

A large part of Lake County is the sandy region—to which we have no parallel—left by the receding of Lake Michigan to its present bounds. There are in northwestern Lake County—the southeast part of the region covered by Higley and Raddin's catalogue—some lakes and marshes which present conditions similar somewhat to our own. These localities in Lake County have been so thoroughly examined that it is not strange to find some of our less frequent species also "very infrequent" there. Most of all the references made are to plants very rare or local in Lake County. Many of our common species would not be found in Lake County, and very many common Lake County species would not be found here at all. While Lake County offers similarities in a small part of its territory, the Lake region of Northeastern Indiana and the Lake County region, as a whole, are dissimilar.

Notes in General, Upon Occurrence and Distribution of Rare or Interesting Species.

Those who have published lists covering any part of Northeastern Indiana do not claim them to be complete, and doubtless new plants are yet to be observed. By comparing the partial catalogues referred to with my own collections I find a total of some nine hundred and fifty species reported from the "Lake Region of Northeastern Indiana."

It is to be regretted that Mr. Bradner has not given in his catalogue[18] any notes as to abundance of species, or to distribution over the territory. With the exception of one or two instances it is impossible to tell whether a supposable rare plant is rarely or more commonly met with, or in what kind of soil, or under what conditions it is found. If scarce, whether it is recently noticed and just appearing, or whether formerly seen and just disappearing. With the geology of the county given by townships in the same volume, Mr. Van Gorder's reference[19] to scarcity or abundance, and to locality by townships, is very helpful.

It would seem that much more importance should be placed on these annotations than is often done. The helpfulness of richly annotated lists is double that of those with bare names of species.

[18] 17th Rep. State Geologist Ind. 1891-2, p. 135.
[19] 18th Rep. State Geologist Ind. 1893, p. 33.

PLANTS NOT GIVEN IN COULTER'S LIST.[20]

During my collecting in Kosciusko County I have found seven plants not reported in Coulter's List. On the sandy, low shore of Chapman's Lake, Kosciusko County, I found, in 1894, *two specimens only* of *Epilobium Adenocaulon* Haussk. Although growing very near each other they have a very different aspect, and so far as I could judge from the manual description I had a specimen of *E. glandulosum* Lehm., which Trelease says[21] does not occur in the United States. The specimens were both sent to Dr. Trelease, and he writes me that they are both *E. adenscaulon*, much as they appear different; and that *E. adenscaulon* is very variable. So far as I can ascertain *E. adenscaulon* has never been found in Indiana with the exception of the two specimens I possess; and it is interesting to note that Beal & Wheeler[22] do not list it from Michigan farther south than Keewenaw County, the very northermost county of the Upper Peninsula.

Anychia Capillacea DC., I have found in Kosciusko County in two places in quite abundance—on the east shore of Tippecanoe Lake in woods, and in a similar situation in Winona Park, Winona Lake. The manual[23] says, "More abundant northward," but it is not given by Beal & Wheeler, as found in Michigan, just north of us. Higley & Raddin[24] list it as found in Riverside, Ill., Cook County, but do not list it from Lake County, in their list of Cook County, Ill., and Lake County, Indiana, plants.

Specimens of *Bidens Beckii* Torr. were found by me in 1893 in the slow waters of the Tippecanoe River, near Warsaw, Kosciusko County. I could find no list of any section in Indiana containing this species, and reported the same to Dr. Jno. M. Coulter. Since then I have found it mentioned as rare in Lake County, and by Bradner from Steuben County.[25] I failed to find it elsewhere, nor could it be found in the same place the next year.

I found, in 1894, a few specimens of *Asclepias phytalorcoides* Pursh.* near Chapman's Lake, Kosciusko County. It is not in Coulter's list, but I have since

[20]Bot. Gazette V, Sup. I, 1882, Flora of Indiana. From which all future references to "Coulter's List" or to the "State Flora" are taken.

[21]Monograph Genus Epilobium, p. 100.

[22]Mich. Flora, 1892, W. J. Beal and C. F. Wheeler, Agricultural College, Mich. From this work all future references to Beal & Wheeler, or Michigan Flora, or to plants of Mich. are taken.

[23]Gray's Manual, 6th Edition. All references to Manual are Gray's 6th Ed.

[24]Bull. Chicago Acad. Sci., Vol. II, No. 1, 1891. From which all future references to Lake County are taken.

[25]17th Rept. State Geologist Ind., 1891-2, p. 135. From which all future references to "Bradner's List" or "Steuben Co." are taken.

found it reported from Lake County "rare," from Central Eastern Indiana[26] "rare," but more common in Noble County[27] and Steuben County than elsewhere, showing that this lake region must offer peculiar suitable conditions for its growth.

Trifolium Hybridum L. is fast becoming common in this flora, and is mixing so with *Trifolium repens* L., it seems quite impossible to find T. *repens* very often true to the type. It is reported from the other counties of this region as quite common, while to the northwest, in Lake County, it is listed as infrequent, as also in Beal & Wheeler's "Michigan Flora."

Boutelona racemosa Lag. I found this last summer (1896), on a hillside in Winona Park, Kosciusko County; very abundant in one plat about one rod square, but seen nowhere else. It is not listed by Troop in his "Grasses of Indiana,"[28] nor do I find it listed anywhere from Indiana except by Bradner, from Steuben County, in this region.

Eleocharis quadrangulata R. Br., is not listed by Dr. Coulter, but is marked "rare" in the Manual. This was found last summer (1896) in Winona Lake; quite abundant in one locality. It is reported from South Michigan as rare, and from Steuben County by Bradner. Outside of these two reports from this region, I find only one other report from Indiana, and that in the appendix to the Lake County list, *in one locality only.*

PLANTS IN COULTER'S LIST, BUT NEW TO OR RARE IN THIS REGION.

Eleocharis ovata R. Br., though given in Coulter's List as common to the State, is not reported in any local list of the south part of the State at my command, and is "infrequent" in Michigan to the north, but I found a few specimens at Winona Lake, Kosciusko County, and it is reported from Steuben County, this region. This northeast part of Indiana would seem to be more suited to it than other parts of the State. It is "very infrequent" in Lake County.

Hibiscus Moschentos L. is only reported from the "knobs" in Coulter's list, and I can find no other report of it from this State than in Lake County. I found a large clump of it on the Tippecanoe River, Kosciusko County, in 1893.

In 1894 I found about six plants of *Parietaria Pennsylvanica* Muht., on a sandy shore of Turkey Lake, Kosciusko County. Coulter's list reports it only from the banks of the Ohio. I can find no other locality in the State from which it is reported, except from Lake County, and then marked "rare."

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[26] 12th Rept. State Geologist, 1882, "Flora of Central Eastern Indiana," A. J. Phinney, M. D., p. 196. From which all references to Cent. Eastern Ind. are taken.

[27] 18th Rept. Ind. State Geologist, 1893, p. 33. From which all future references to "Noble Co." or "Van Gorder's List" are taken.

[28] Bull. 29 Ind. Agri. Expt. Sta., Lafayette, Purdue Univ., 1889. "Grasses of Indiana." —J. Troop.

I found in 1893, on waste ground, Kosciusko County, one specimen of *Ipomœe hederacea* Jacq., which is the only discovery of the species I can find north of Central Indiana, nor is it reported from Michigan, to the north.

A few specimens of *Myriophyllum heterophyllum* Michx., which I found in Boydston's Lake, Kosciusko County, are the only plants of the species I can find reported from the north part of the State, but from Steuben County, this region, and from Lake County.

I would add Kosciusko County as another locality, for four plants mentioned in Dr. Stanley Coulter's paper[29] before the Academy last year, as occurring at only one or two stations in the north part of the State.

They are *Liparis lœselii* Richard., *Menyanthes trifoliata* L., *Aster umbellatus* Mill., and *Galium boreale* L. Other plants, not previously reported from the north part of the State, or if so, only from Lake County, could be stated as having been found in this Northeastern Indiana Lake Region.

SOME GENERAL OBSERVATIONS.

In this connection I would call attention to the listing of *Prunus Pennsylvanica* L. f., in a list of the *common* timber trees of seven counties in this immediate section.[30] Is this not a mistake? Should it not be *Prunus serotina* Ehoh.? *P. Pennsylvanica* is not in Coulter's list, and is not reported from this region by any list whatever other than this reference. It is marked "very rare" from Central Eastern Indiana, and also "rare along the lake shore," in Lake County. Beal & Wheeler say in "Michigan Flora," "Very abundant on sandy soil in the north half of the State, but less common southward, where *P. serotina* takes its place." *P. serotina* is surely the only wild cherry here which could be used for lumber (the only other tree of this genus found here—*P. Americana* Marshall—being too small), and should be substituted in the list referred to for *P. Pennsylvanica*.

I would also call attention to some species listed by Bradner & Van Gorder, which appear to me to be probable errors.

Mr. Van Gorder lists from Noble County, "*Hepatica acutiloba* DC., Liver leaf, common"; as does also Mr. Bradner, from Steuben County, and neither list *H. triloba* Chaix. In all my collecting in Kosciusko County I have never seen *H. acutiloba*, while *H. triloba* is one of our most common spring plants. I am well aware that the two species are apt to approach each other, and that transition forms are apt to be found, but am well acquainted with the two species, having been able to find at Crawfordsville, Indiana, with close searching for two

[29]Proc. Ind. Acad. Sci., 1895, p. 183.
[30]5th Rept. State Geologist Ind., 1873. Observations by G. M. Levette, p. 434.

seasons, nothing but *H. acutiloba*, and find nothing in Kosciusko County but *H. triloba*, the scapes of which seldom grow to the height of those of *acutiloba*.

It would seem strange that such an apparent difference should exist between counties of the same region, and I feel quite certain, since these lists report but *one* form, it must be *H. triloba*.

Mr. Bradner lists from Steuben County, "*Claytonia Caroliniana* Michx., Spring Beauty." Mr. Van Gorder reports from Noble County only *C. Virginica* L., and that is the only species reported from Kosciusko County.

It is not at all probable that *C. Caroliniana* is found so far south in this longitude. Beal & Wheeler say *Caroliniana* is not found in the *south* part of Michigan. It is reported from Lake County, where the conditions are more like those of Northern Michigan, and it seems very certain that the plants referred to in Mr. Bradner's list should be written *C. Virginica*.

Nowhere can I find *Viburnum nudum* L. reported outside the limits given in Gray's Manual, 6th edition, viz.: "From N. J. to Florida," except from Steuben County by Bradner, and if it be correct, is worthy of mention as an entirely new plant to this region.

Mr. Bradner also reports *Typha augustifolia* L. from Steuben County, which is very rare indeed, and deserves special notice.

I have not corresponded with either Mr. Van Gorder or Mr. Bradner, nor seen their collections, and draw the above conclusions wholly from general observation.

It is worthy of note that *Nelumbo lutea* Pers. is reported from Blue River Lake, Whitley County[31]—a part of this region. This is the only reported locality in Indiana, except Lake County, and the species is very rare in the Central States.

This region, as a whole, seems to possess a flora considerably different from that which it had a decade since; to have lost many of its northern forms, and to have gained some southern forms. Introduced species from the east and west have been brought in by the railroads. The climate is much milder than formerly, and the various conditions for plant growth materially changed. Until recently it has not had as much attention from botanists as other sections of the State.

A more careful study of the flora will surely develop interesting facts. There is much to be done along the line of cryptogamic botany. Surely the territory as outlined is worthy the designation of a separate and characteristic region, and will repay the more extended investigations of botanists.

[31] 17th Rept. State Geologist Ind., pp. 166.

CONTRIBUTIONS TO THE FLORA OF INDIANA, NO. IV. BY STANLEY COULTER.

The preceding papers in this series are those entitled *Saxifragaceæ of Indiana* (Proc. Ind. Acad. Sci., 1894, pp. 103–107); *A Preliminary List of Plants Growing in the Vicinity of Washington, Daviess County* (Proc. Ind. Acad. Sci., 1895, pp. 169–182); *Noteworthy Indiana Phanerogams* (Proc. Ind. Acad. Sci., 1895, pp. 183–198). The notes are incidental to the preparation of the catalogue of the flora of the State, and are in a measure supplemental to that work.

Many plants which were originally included in this contribution have been omitted, because of their inclusion in much fuller detail than I could possibly have given in the papers of Messrs. W. S. Blatchley and Robert Hessler, M. D., published in these proceedings. With the exception, therefore, of a few forms to which I desire to call attention, the body of this paper concerns the compositæ of the State, with special reference to their distribution.

Coptis trifolia Salisb. Mr. Van Gorder reports this plant as very abundant in certain localities in both Noble and DeKalb counties. So far as has come to my knowledge, this is the only record of the plant in the State authenticated by herbarium specimens. Its range and habits of growth would indicate its presence in the swamp regions of our northern counties.

Ailanthus glandulosus Desf. This tree, not as yet included in the lists of the forest trees of the State, seems to have become thoroughly naturalized, and is entitled to a place in our flora. In Jefferson county it has escaped from cultivation and covers entire hillsides, notably in the vicinity of Madison and Hanover college. The growth is so dense and rapid as to make it a somewhat doubtful acquisition. A thicket of *Ailanthus* in full foliage gives a very fair idea of the appearance of semi-tropical undergrowth. The tree should be included in the flora of the State.

Sullivantia Ohionis Torr. and Gray. This form, the distribution of which I limited (*Saxifragaceæ of Indiana*, Proc. Ind. Acad. Sci., 1894, p. 104) to a single station at Clifty Falls, Jefferson county, must have an added station in Clark county. The determination of Dr. C. R. Barnes, questioned in that communication, has been verified by abundant specimens found among the duplicates in Purdue university. The Clark county station is of the same general character as that at Clifty Falls, the plant clinging to the vertical sides of moist limestone cliffs, by no chance seeming to leave this apparently barren position for the deeper and richer soils surrounding. The plant in our region may be considered as the most characteristic of the limestone cliffs.

Juniperus Virginiana L. The apparently rapid increase of this cedar throughout southern Indiana is worthy of note. Within ten years the number of well-grown forms has increased at least fourfold. The explanation of this increase is to be found in the almost universal fencing of regions formerly wild, and the consequent restriction of cattle ranges. It is an extremely suggestive example of the almost immediate effect of a modification of the factors entering into the struggle for existence. It is incidentally suggestive of the fact that when reforestration is attempted, the young forest areas must be as carefully guarded as are flower or vegetable gardens.

Tipularia discolor Nutt. This rare orchid is reported by Prof. A. H. Young as having been found at the Clifty Falls station, in Jefferson county, the past season. This is much south of its central range, although in its easterly range it extends as far south as Florida.

The plant affects sandy woods, while the Clifty Falls Station can offer nothing except a thin limestone soil or a heavy, cold clay. The record is verified by herbarium specimens.

The compositæ of Indiana, so far as reported to the survey, number 213 species, distributed through 55 genera. The *Asters* lead with 32 reported species, *Solidago* coming second with 28. The other larger genera are *Helianthus*, 13 species; *Eupatorium*, 7 species; *Erigeron* and *Coreopsis* each with 6 species; *Bidens*, *Silphium* and *Liatris* each with 5 species. Owing to imperfect notes and "scrappy" material the work, especially in the *Asters* and *Solidagos*, was extremely difficult. While doubtless many errors occur, there has been a constant endeavor to eliminate all doubtful references. In some cases specimens have not been seen, but where admitted the original specimens have been passed upon by some well-known expert. Very few of Dr. Schneck's specimens have come into my hands, but all of his doubtful forms were referred at the time of collection to Dr. Gray. It may be assumed that all admitted forms have been inspected or passed upon by some botanist entitled to speak with authority.

It may be intimated here that apparently no other family responds so quickly to changed conditions. The response, even to slight changes, is often very marked. Many *Asters* and some *Solidagos* present fairly distinct forms, determined apparently merely by the amount of light or shade. Others indicate clearly the amount of moisture in the soil. Because of this ready response to environmental changes a determination of a form from a single specimen is often an impossibility. I have felt compelled in some cases to omit from the list forms of apparently correct determination until fuller notes or a larger suite of specimens proved them not to be environmental variations.

With but few exceptions, the composites within our bounds do not come into full flower until July and August. As a rule the flowering season is long, many genera blossoming abundantly from July until checked by the frosts. From the middle of August they determine the physiognomy of the vegetation over the entire area of the State. This is especially true in the prairie region and in open fields. Indeed, the great majority of the composites of Indiana are found in their greatest abundance and luxuriance in dry soils and in regions exposed to the full action of the sun. They seem to be xerophytes of the xerophytes.

Some species of *Eupatorium*, *Liatris spicata* and other forms, however, furnish exceptions as regards dryness of soil, while *Polymnia* and a few others give exception as to light. Certainly in no other family in our area can xerophytic adaptations be so satisfactorily studied.

While the flowering season is so extended, and the consequent number of achenes formed enormous, it is probable that but a small proportion of them germinate. The seedlings, also, in all cases in which experiments were tried, were remarkably sensitive to changes in temperature and moisture. Almost every other form used was more hardy in the seedling stage than the compositae. Exceptions to this were the *Ambrosias* and *Lactuca Canadensis* L. In the series of experiments the percentage of seeds germinating was very small in the compositæ, with the exception of *Arctium*, where the per cents, in three experiments were, 87.5, 80, and 87.5. In *Bidens* 20 per cent. was the highest, in *Lactuca* 25 per cent., in *Ambrosia* 20 per cent., while in *Cnicus* out of three plantings of 30 achenes each, only two achenes germinated. Under the same conditions *Abutilon Avicennæ* Gaertn, in two experiments gave 100 per cent., and in a third, 96.7. The seedlings of this plant were extremely hardy, withstanding wide ranges of temperature and moisture. *Solanum nigrum* L , *Datura stramonium* L., and *Scrophularia nodosa* L., *Marilandica* Gray, invariably showed germination per cents. above eighty-five. The plants, other than composites, are introduced simply for purposes of comparison. The data given above are derived from a large number of germination experiments conducted in the Laboratories of Purdue university. In these experiments I have endeavored to eliminate possible error. and to give, so far as could be determined, natural conditions. The experiments cover some 30 composite species distributed among 15 genera, and 50 species representing families other than the compositæ. The material was gathered in almost every instance with extreme care in order that conclusions might be based upon known conditions. So far as the experiments go concerning compositæ, I am convinced that the distribution of this family is largely limited, first, by the small germination percentage of the achenes; second, by the extreme sensitiveness of the seedlings

to heat and moisture changes. A series of pots containing seedlings was subjected to an artificial drought of five days. Of the eleven species of composites all except *Ambrosia* died. Of ten species of other families, only *Scrophularia nodosa Marilandica* died. Repetitions of the experiment showed similar results. Another line of experiments showed that the composite seedlings were unable to withstand any considerable change in temperature, being much more affected by temperature increase than by its decrease. An increase of 5° C., from 25° C. to 30° C, usually proving sufficient to kill them or greatly retard their growth. When it is remembered that the distribution of composites is for the most part in dry soil, in places exposed to the full force of the sun, it is apparent that large numbers of seedlings must perish. It is possible that the danger of a spread of these forms through seed dissemination has been overestimated.

Another fact indicated by the experiments was that the achenes of the earlier and later flowers were rarely viable, this being especially true in *Helianthus*.

It is somewhat surprising that in a family so dominating in species and individuals there is not included a greater number of "worst weeds." Considering the immense size of the family, the number is astonishingly small.

Taraxacum invades the lawns; the *Lactucas*, *Cnicus*, *Arctium* and *Erigeron* the fields; but none of them compare in noxious features with forms from other families. *Ambrosia*, which overruns waste fields, I find is considered by the farmers as a positive benefit to the land. *Erigeron*, which a few years ago was a great annoyance, seems to have yielded to cultivation, and to have practically lost its place among bad weeds. Doubtless in some places it is still annoying, but the evidence is that it disappears from carefully cultivated fields. *Chrysanthemum Leucanthemum* L. is certainly bad, but is of restricted range. *Bidens* is annoying to the sheep-raiser, but does not otherwise rise to the rank of a "bad" weed. For the most part the compositæ seem perfectly content to occupy waste places, and readily yield to man the possession of the soil.

So far as I have been able to discover, none of the species are poisonous, if I except a few reported instances of poisoning by forms of *Cnicus*. Most of these cases, I think, can be referred to personal idiosyncrasy. I have tested all the forms of *Cnicus* upon myself and upon numbers of students without results other than were referable to the mechanical action of the prickles. *Xanthium Canadense* Mill. is said to be poisonous to the touch.[1] If this be true, the forms found in the State, *X. spinosum* L. and *X. strumarium* L., are to be regarded with suspicion by persons susceptible to plant poisoning. It is to be remembered, however, that even the known poisonous plants are only poisonous to a small percent-

[1] White, *Dermatitis venenata*. Boston, 1887.

age of those touching them, and many are only poisonous in certain stages of their growth.

Save for the medicinal value of some few forms, none within the State are of economic value, if Jerusalem artichoke (*Helianthus tuberosus* L.) and the Dandelion (*Taraxacum officinale* Weber), both of which are occasionally used as food, are excepted.

Very few of the compositæ are eaten by animals, except by accident or under pressure of hunger. They are also largely free, at least the Indiana forms, from plant diseases. Their limitation in numbers and distribution I believe to be largely determined by the causes named earlier in this paper.

It is not the purpose of this paper to give a full list of the forms found in the State, but rather to call attention to the more general facts concerning their distribution.

I. LOCAL FORMS.

The species included in this list, so far as has come to my knowledge, are only reported from a single locality. A close examination of the list will show that in many cases this apparently restricted State range is but an indication of territory that has been closely and continuously worked.

Vernonia altissima Nutt. Reported from Tippecanoe county by Messrs. Laben and Conner. The distinction between this form and *V. fasciculata* Michx., turns upon the character of the inflorescence and the surface of the achene. Any one familiar with the varied inflorescence of *V. fasciculata* will see that the ultimate distinction is upon the character of the achene. In *fasciculata* the achene is smooth; in *altissima* hispidulous on the ribs. In the specimens reported the achenes were hispidulous on the ribs and the plant was referred to *altissima* Nutt. Further examination of the genus showed that the achenes of *V. Noveboracensis* Willd., showed the same characters. The character of the involucral scales, however, excludes the form from *Noveboracensis*. *V. altissima* Nutt. is, therefore, added to the State flora. In a general way the plant has the inflorescence and achene of *Noveboracensis*, the involucral scales of *fasciculata*, and leaves intermediate between the two. Its appearance is strongly suggestive of the possibility of its being a hybrid form.

Mikania scandens L. Reported from Gibson and Posey counties by Dr. J. Schneck. "Sandy thickets along streams; rare."[2] There seems to be no reason

[2] 7th Rep. Geol. Surv. Ind., 1875, p. 535.

why this plant should not be found in other localities. It, presumably, from what is known of its distribution, came into the State from the north and east.*

Liatris squarrosa Willd. Gibson and Posey counties, Dr. J. Schneck. "Dry soil; rare."[3] Another form which is probably of much wider range than present reports indicate.

Chrysopsis villosa, Nutt. Reported from Vigo county by W. S. Blatchley. "Frequent; banks of old canal, prairies, etc."[4] This species has evidently entered our territory from the west and may be found in the western tier of counties.

Solidago squarrosa Muhl. Reported from Floyd county in 1837 by Dr. A. Clapp, and not since recorded in the State. A number of species found in the Clapp collection are in similar case. Their disappearance from our flora emphasizes the importance of continuous regional study in order that we may have more accurate knowledge of plant movements.

Solidago petiolaris Ait. Specimens by Baird and Taylor from Clark county have been referred to this species. The specimens are not entirely satisfactory, but there seems no doubt of the accuracy of the reference. The plant entered the State flora from the southwest.

Solidago odora Ait. Gibson and Posey counties, Dr. J. Schneck. "Sandy soils, scarce."[5] Specimens have not been examined, but the species is admitted for reasons indicated earlier in the paper.

Solidago rupestris Raf. Reported from Clark county by Baird and Taylor. The inclusion of Indiana in the range of this species in the 6th edition of the Manual was doubtless based upon this collection.

Brachychæta cordata Torr. and Gray. Jefferson county. For full notes on this form reference is made to *Noteworthy Indiana Phanerogams*, in Proc. Ind. Acad. Sci., 1895, p. 189.

Sericocarpus solidagineus Nees. In the Clapp collections of 1834-37, from Floyd county. It does not seem to have been recorded since that time.

Aster macrophyllus L. This form from the north is reported from Noble county, by Mr. W. B. Van Gorder.

Aster Drummondii Lindl. Reported as "frequent in low, open pastures and prairies"[6] in Vigo county, by W. S. Blatchley. A western form very close to *A. sagittifolius* Willd., and possibly a mere geographical variety.

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[3] Ibid, p. 534.

[4] Blatchley, W. S., Compositæ of Vigo County. In ed.

[5] 7th Rep. Geol. Surv. Ind., 1875, p. 536.

[6] Blatchley, W. S. Compositæ Vigo county. In ed.

* Since this was in type, Mr. W. S. Blatchley, under date of September 26, 1897, sends me abundant specimens of this form from Lake county. He reports it as "growing plentifully over bushes on the mucky margin of a stream, four miles east of Hebron."

Aster vimineus Lam., *foliolosus* Gray. This form is reported from Franklin county by O. M. Meyncke. So far as I am able to judge the reference is correct, although the well-known difficulty of separating the group of species in which it is found renders absolute certainty impossible.

Aster junceus Ait. Reported from Clarke county by Baird and Taylor is in all probability *not* a member of the State flora. The very scant specimen I have examined from the Clark county locality is probably *A. Novi-Belgii* L. As the specimens fit the latter as well as they do *junceus*, range probabilities lead to the exclusion of *A. junceus* Ait., from the State flora.

Ambrosia bidentata Michx. Reported as "common, dry prairies"[7] in Gibson and Posey counties by Dr. Schneck. From the west and probably to be found as far north as Vermillion county, although the Gibson and Posey county station the only one reported.

Rudbeckia speciosa Wenderoth. Reported from Jefferson county by J. M. Coulter. The specimen has not been examined, but is admitted upon the authority of the collector.

Rudbeckia fulgida Ait. Reported by Dr. A. J. Phinney from Jay, Delaware, Wayne and Randolph counties. Dr. Phinney states that his specimens were verified by Dr. John M. Coulter. The species is therefore admitted, although so marked a form should not rest upon a single reference.

Helianthus rigidus Desf. Jay, Delaware, Wayne and Randolph counties, Dr. A. J. Phinney. The form is very characteristic and could scarcely be mistaken. It is probably a member of the State flora, although its more natural location would be the western portion of the State.

Helianthus occidentalis Riddell. St. Joseph county. Reported by Dr. Charles R. Barnes and verified by abundant specimens.

Helianthus tomentosus Michx. Reported from Clark county by Baird and Taylor, is probably an incorrect reference. No specimens have been examined and the range probabilities are sharply against its presence in the State.

Coreopsis auriculata L. Clark county, Baird and Taylor.

Coreopsis discoidea Torr. and Gray. A specimen of this species is in the Purdue herbarium labelled Gibson county. No collector's name is given. The plant is not included in Dr. Schneck's *Flora of Lower Wabash Valley*. The identification is correct, the only question which arises is concerning the locality. I know of no collector other than Dr. Schneck in that region. Upon the specimen, the species is admitted to the flora.

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[7] 7th Geol. Rep. Ind., 1875, p. 537.

Bidens Beckii Torr. Reported by W. W. Chipman from a single locality in Kosciusko county. Mr. Chipman secured abundant material of this interesting species which is northern in mass distribution.

Hymenopappus scabiosaeus, L'Her. "Scarce on sandy knolls"[8] in Vigo county Reported by W. S. Blatchley. This is only one of a large number of plants added to our flora by the careful investigations of Mr. Blatchley. The plant entered the State from the southwest. Verifying specimens in De Pauw university herbarium.

Artemisia Canadensis Michx. Lake county, E. J. Hill. For full report see *Noteworthy Indiana Phanerogams*, Proc. Ind. Acad. Sci., 1895, p. 191.

Artemisia annua L. A Gibson county specimen with no further data. Investigation indicates that it is probably not uncommon in the State, although not definitely reported from other localities.

Artemisia Absinthium L. Escaped and well established in Gibson and Posey counties. Not reported from any other locality.

Senecio palustris Hook. This species, reported from Clay county by D. T. MacDougal, is represented by specimens in the DePauw herbarium. I have examined the forms and believe the determination accurate. Range probabilities would suggest the form to be *S. lobatus* Pers., but the "*20 or more rays*" seem sufficient grounds for holding to the original reference. It is probable that the range as indicated in the manual should be somewhat extended southward.

Cacalia tuberosa Nutt. Reported from LaPorte, LaPorte county, by Dr. C. R. Barnes. I have also found this species in fair abundance in the low ground to the south and west of Pine Lake, near LaPorte. Abundant herbarium specimens verify the reference. The form has probably a much more general distribution through the northern portion of the State in wet lands.

Cnicus horridulus Pursh. Reported from Putnam county by D. T. MacDougal, with verifying specimen in herbarium of DePauw university. The reference is incorrect. The specimen is *Cnicus lanceolatus* Hoffm., in which the leaf prickles have a yellowish caste. With this exception the form is the typical *lanceolatus*. *Cnicus horridulus* is a coast plant, and should be excluded from the State flora.

Cnicus Pitcheri Torr. Lake county, E. J. Hill.[9]

Cnicus pumilus Torr. Lake county, E. J. Hill.[10]

Cnicus Hillii, W. M. Canby. Lake county, E. J. Hill.[11]

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[8]Blatchley, W. S.: Compositæ of Vigo county. In ed.
[9]Coulter, Stanley: Noteworthy Indiana Phanerogams, Proc. Ind. Acad. Sci., 1895, p. 193.
[10]Ibid., p. 193.
[11]Ibid., p. 193.

Cichorium Intybus L. Reported from Noble county by W. B. Van Gorder. This form escapes readily from cultivation, and to my personal knowledge has made a foothold for itself in several localities in the State. This is notably true in Jefferson county. The only specimens, however, are from Noble county.

Hieracium Canadense Michx. Reported from Lake county by E. J. Hill. The form will probably be found to be confined to the northern counties in favorable localities, its mass distribution being northerly.

Hieracium longipilum Torr. "Prairies and open woods, common,"[12] Gibson and Posey counties, Dr. J. Schneck. From the north.

Prenanthes serpentaria Pursh. Listed from Clark county by Baird and Taylor. No specimens have been examined. The species is eastern in its distribution, and the reference is probably incorrect. Excluded from the State flora in absence of verifying specimens.

The following forms seem to be limited within the State to the northern counties:

Solidago stricta Ait. Reported from St. Joseph county by Dr. C. R. Barnes, and from Noble county by W. B. Van Gorder. From the north, and probably to be found in favoring localities in low, damp ground in the northern tier of counties.

Solidago uliginosa Nutt. Lake, St. Joseph and Noble counties.

Solidago Riddellii Frank. Reported from Noble county by W. B. Van Gorder; from Tippecanoe county by Prof. Hussey; from Jay, Delaware, Randolph and Wayne by Dr. Phinney. The Noble county reference is well authenticated and sufficient to admit form to State flora. The Tippecanoe county specimen is unsatisfactory, being both scant and incomplete. No special feature excludes it from the reference, nor, on the other hand, does any marked character require the reference. I am inclined to think the Tippecanoe county specimen, *S. Ohioensis*, Riddell, a species of known occurrence in the county. Dr. Phinney's specimens are not accessible. As it stands, Noble county is the only authenticated station for the species.

Solidago tenuifolia Pursh. Reported from Jasper county by Dr. C. R. Barnes, and authenticated by abundant specimens in the Purdue herbarium. Also included by Dr. Phinney in his list of Jay, Delaware, Wayne and Randolph counties.

Coreopsis palmata, Nutt. Laporte and St. Joseph counties, reported by Dr. Barnes. Specimens in Purdue herbarium. Probably from the northwest.

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[12] 7th Geol. Surv. Ind. 1875, p. 541.

Artemisia caudata Michx. This species, which has heretofore had its sole station in Lake county, but which I intimated should be found more widely distributed,[13] has an additional station reported in Fulton county by Dr. Robert Hessler. The specimens were examined and are unquestionable.

Artemisia Canadensis Michx.[15]

Prenanthes racemosa Michx.[14] Formerly reported only from Lake and Noble counties, has been reported from Cass county by Dr. Hessler. Abundant specimens were submitted to the survey.

The following species, so far as can be determined, seem to be restricted in range to the southern portion of the state. It is probable, however, that more extended study will extend many of these ranges.

Elephantopus Carolinianus Willd. Reported only from Gibson, Posey, Jefferson, Clark, Daviess and Vigo counties.

Eupatorium cœlestinum L. Reported from Gibson, Posey, Jefferson, Franklin, Monroe and Daviess counties. There seems to be no reason why it should not be found throughout the State, as the mass distribution of the form is northward.

Solidago neglecta Torr. and Gray. Reported from Jefferson county by John M. Coulter, and from Clark county by Baird and Taylor. The Clark county specimen has not been examined. The Jefferson county specimen in the Purdue herbarium is *S. arguta* Ait. In absence of further data, the form is excluded from State flora, the range probabilities being against its occurrence in the localities cited. If found in the State it will probably be in the swamps of the northern counties.

Solidago Shortii Torr. and Gray. Floyd county, 1837, Dr. A. Clapp. Reported also from Clark county by Baird and Taylor. Indiana probably represents the eastern limit of this species.

Boltonia asteroides L' Her. Reported from Gibson, Posey and Jefferson counties. Also included in Dr. A. J. Phinney's list of the central-eastern counties.

Aster ericoides L., *villosus* Torr. and Gray. This variety should be, and probably is, fairly abundant in the State. It is, however, only definitely reported from Jefferson, Franklin and Vigo counties.

Erigeron divaricatus Michx. In the Sixth Edition, Gray's Manual, the range given is "Indiana to Minnesota, and southward." The species, however, is only reported from Jefferson, Gibson and Posey counties. In both localities it is said to be "not abundant."

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[13] Coulter, Stanley: Noteworthy Indiana Phanerogams. Proc. Ind. Acad. Sci., 1895, p. 191.

[14] Ibid., p., 192.

[15] Ibid., p. 191.

Pluchea camphorata DC. In Jefferson county, on river banks. In Gibson and Posey counties, "common in rich clearings and moist glades."

Polymnia Uvedalia L. A species found in moist and miry places. Reported only from Gibson, Posey, Jefferson, Franklin and Clark counties.

Eclipta alba, Hassk. Probably occurring throughout State, but, so far as reports go, not found north of Johnson county. Very abundant and variable in the more southern counties.

Heliopsis laevis Pers. Reported stations of this species indicate that it is not found farther north than Johnson county. As in the preceding species, its mass distribution in the State is evidently southern.

Heliopsis scabra Dunal. Reports indicate this species to be southern in its distribution. Putnam county represents the northern station in the State.

Helianthus parviflorus Bernh. This form is reported from Gibson, Posey, Jefferson and Franklin counties, and in the list of Dr Phinney.

Helianthus doronicoides Lam. Is reported from the same localities as the preceding species, with Putnam county as an added station. There is no apparent reason why both forms should not be of more general distribution.

Anthemis arvensis L. Reported from Monroe and Clark counties. The occurrence of the species within our boundary is exceptional, and it is a question as to whether it has maintained its place in the localities in which it was found.

Chrysanthemum Parthenium Pers. Reported from Gibson, Posey and Clark counties. The position of these "escapes" in a local flora is very questionable. I am inclined to exclude such forms from the State list unless the form generally escapes from cultivation and successfully maintains itself for a series of years.

Onopordon Acanthium L. Doubtfully admitted on reports from Jefferson county by Dr. John M. Coulter, and from Clark county by Baird and Taylor.

Centaurea Cyanus L. This species undoubtedly escapes at times from cultivation. It is so reported from Gibson, Posey, Clark and Monroe counties. Its admission to the State flora will depend upon proof that it has maintained itself in the localities in which it has escaped.

Hieracium paniculatum L. Reported from Clark, Monroe, Jefferson and Harrison counties. While no range improbabilities intervene the somewhat scant specimens examined are perilously close to *H. scabrum* Michx. The well known variability of the latter species in our range leads to a slight degree of uncertainty in the reference. The number of flowers in the head, 12–20, however, determined the reference.

Hieracium venosum L. This species is reported from the "Knobs" by Dr. Barnes and from Monroe county by Mr. Blatchley. Its mass range is decidedly

to the north of these localities, and it may be looked for with confidence in the northern portions of the State.

Prenanthes aspera Michx. As reported, this species is confined to Jefferson and Clark counties. There is reason to believe it of more general distribution.

Lactuca hirsuta Muhl., *L. Floridana* Gaertn. and *L. leucophaea* Gray, are all confined to the southern counties, Monroe being the extreme northern reference in any case.

Only one form appears to be strictly western in its State distribution.

Solidago Missouriensis Nutt. This species is reported from Jasper county by Prof. Barnes, but with this exception is confined to counties bordering the Wabash River as far south as Gibson and Posey.

It is thus seen that 36 species have a *single* reported station; that 8 species are strictly northern, 24 species southern and 1 species western in distribution within our territory. The range of many of these 69 species will doubtless be extended as the result of further study. The remaining 144 species of the family are so generally reported, or are reported from such widely separate stations as to make it probable that they are found throughout the State in greater or less abundance. In many cases the distribution of these general forms is so thoroughly worked out as to give with a fair degree of certainty the determining factors in the distribution. It is impossible in this paper to give in detail illustrative cases. In a general way, water courses may be said to be an important determining factor. In the case of *Liatris pycnostachya* Michx., a prairie form, the southward extension of the species from the prairie region is found to follow closely the course of the Wabash River as far south as Gibson and Posey counties. The same thing is true in a less marked degree of *Eupatorium sessilifolium* L., which nowhere wanders far from water ways.

The prevailing winds play a large part in the direction of movement of composite species. After lodgment has once been obtained, the direction in which any given form spreads seems in many cases to be absolutely conditioned by the direction of the prevailing winds at the season of the dissemination of the achenes. A number of lines of distribution are easily attributable to this conditioning factor.

The great trunk lines of railway may serve to introduce new forms, many may find lodgment because of impure seed supplies furnished the agriculturists, but the after distribution, with but few exceptions, is determined by water courses and prevailing winds.

To a slight degree within our area the elevation seems to determine distribution. Thus our extreme southwestern counties are but 300 feet above sea level,

while the remainder of the State ranges from 700–1,100 feet above sea level. A single instance illustrates the point. *Solidago latifolia* L. is found abundantly throughout the State, with the exception of the extreme southwestern counties. It is found, however, in the higher land a little to the west in Illinois, and a little to the south. Other forms occur which indicate that even a slight change of elevation may at times enter as a very positive factor in distribution.

I ask the botanists of the State in their future study of composite forms to devote more time and care to ecologic observations, since by this means only can our State flora be made of such nature as to be readily correlated with work done in other parts of the country. Many lists are a weariness to the flesh, but ecologic facts do good as a medicine.

ADDITIONS TO THE PUBLISHED LISTS OF INDIANA CRYPTOGAMS. BY LUCIEN M. UNDERWOOD.

The following plants, mostly collected during my connection with the State Biological Survey, have not been reported as growing in Indiana, and may properly be noted in this connection. All are represented by specimens in my herbarium:

UNREDINEÆ.

Aecidium Cyparissiæ DC. On *Euphorbia commutata*, Montgomery, 5, 1895 (Olive).

Coleosporium ipomoeæ. On *Ipomoeæ pandurata*, Tippecanoe, 9 1895 (Arthur).

THELEPHORACEÆ.

Corticium alutarium B. & C. Putnam, 10, 1892.

Corticium calceum Fr. Putnam, 5, 10, 1893; 12, 1894.

Corticium cinereum Pers. Putnam, 12, 1891.

Corticium filamentosum B. & C. Putnam, 10, 1892; 12, 1894.

Corticium lacteum Fr. Putnam, 6, 9, 1893.

Corticium lividum Pers. Putnam, 5, 10, 1893.

Corticium ochraceum Pers. Putnam, 10, 1891.

Corticium portentosum B. & C. Putnam, 10, 1892.

Corticium rubropallens Schw. Putnam, 10, 1893.

Hymenochæte fuliginosa (Pers.) Lev. Putnam, 12, 1894.

Hymenochæte purpurea Cke. & Morg. Putnam, 9, 1893.

Peniophora cinerescens (Schw.) Sacc. Should stand in place of *Hymenochæte cinerescens* previously reported. Putnam, 10, 1891; 12, 1894.

Stereum coffeatum B. & C. Putnam, 12, 1891.

Stereum hirsutum (Willd.) Fr. Putnam, 10, 1893; 12, 1894.

Stereum ochraceoflavum Schw. Vigo, 10, 1893.

Thelephora tephroleuca B. & C. Putnam, 7, 1894 (Melia Ellis).

AGARICACEÆ.

Collybia zonata Pk. At the foot of a maple, Putnam, 8, 1896.

LYCOPERDACEÆ.

Geaster fimbriatum Fr. Putnam, 11, 1894.

Lemanea catenulata grows in abundance, forming fringes on the rocks above the upper fall (Eel River Falls, Owen County), where I collected it in May, 1893. According to Dr. Atkinson this species has not before been reported from America. Its Chantransia stage is still a desideratum. The plant was distributed in Setchell, Holden and Collins: *Phycotheca Americana.*

Additional Hosts for Indiana fungi previously reported.

Carex Pennsylvanica (Puccinia caricis). Montgomery, 5, 1895 (Olive).

Galium aparine (Puccinia galii). Montgomery, 5, 1895 (Olive).

Ipomœa nil (*Albugo ipomœæ-panduranæ*). Tippecanoe, 9, 1895 (Arthur).

Phaseolus diversifolius (*Uromyces appendiculatus*). Tippecanoe, 9, 1895 (Arthur).

Columbia University, 26 December, 1896.

CHANGES IN THE PITH CELL PRELIMINARY TO THE DEVELOPMENT OF CAVITIES IN THE STEMS OF SOME GRASSES. BY GEORGE J. PIERCE.

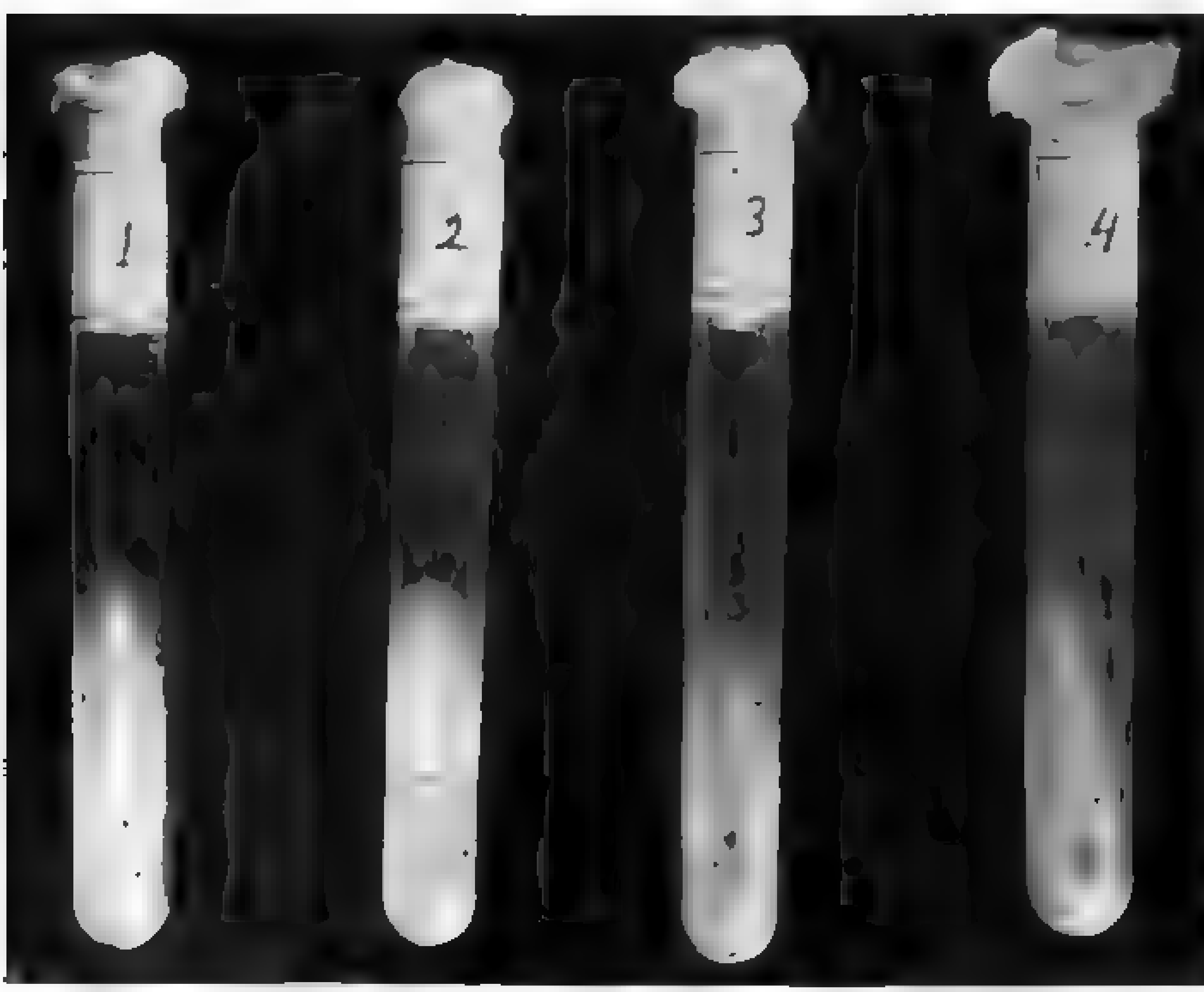
THE BACTERIOLOGICAL FLORA OF THE AIR IN STABLES. BY A. W. BITTING AND CHAS. E. DAVIS.

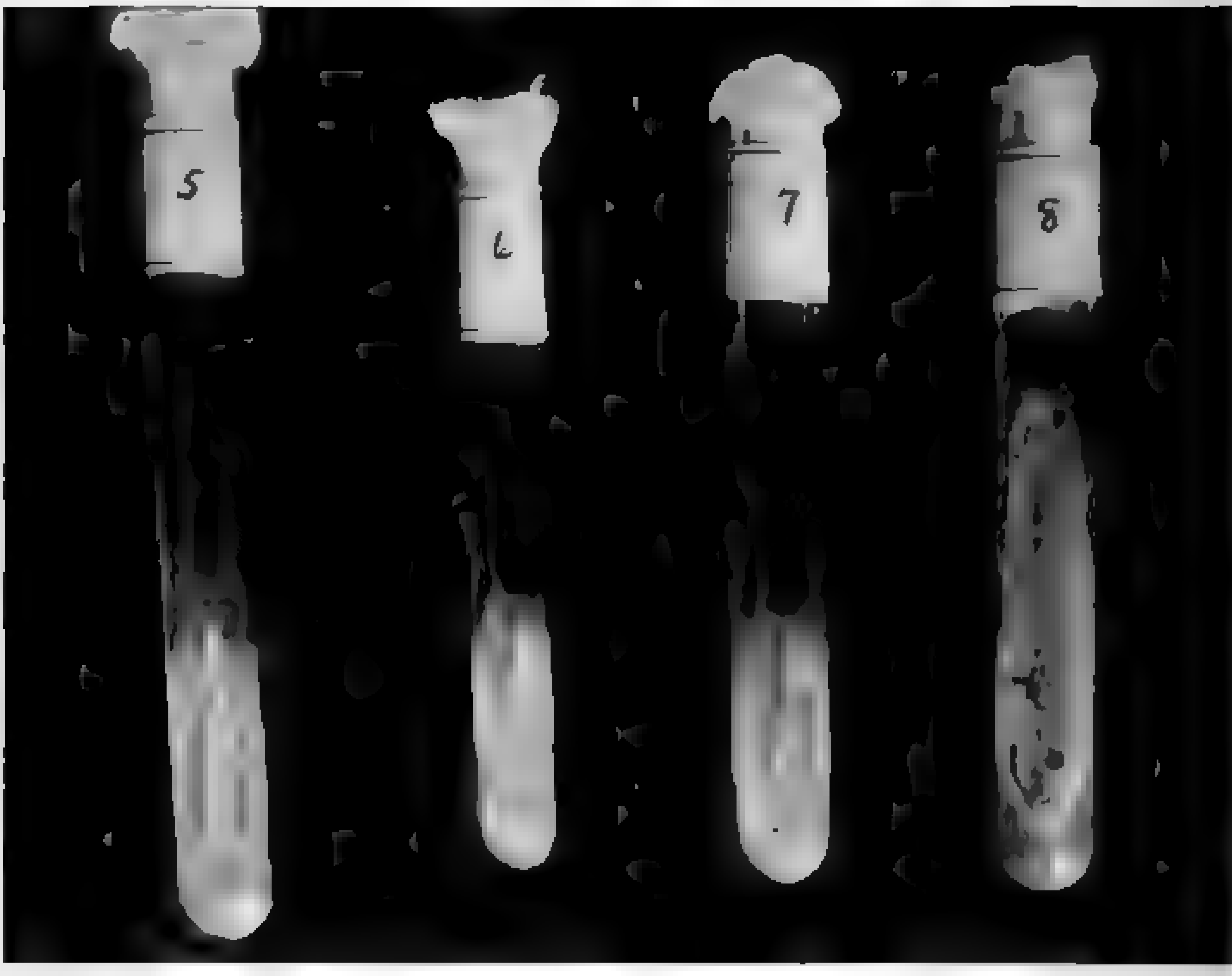
During the first five months of the present year a study was conducted to determine the number of bacteria found in the air in stables and to determine whether a relationship existed between the number of germs found in the air and the sanitary condition of the place.

Ten barns and stables were selected, representing fairly well good, average and poor sanitary conditions. Fifteen tests of the air were made inside the buildings with Hesse's apparatus and a corresponding number of tests made on the open air at the same time. The average number of colonies developed per liter from the air inside the stables was 86; the average number of colonies developed per liter from the air outside the stables was 27. Thirty tests were made by Petri dish exposures for two minutes each in the air inside the stables and fifteen tests

for the same length of time outside the stables. The Petri dish exposures were made at the same time the Hesse tests were made. The average number of colonies grown on the plates exposed inside the stables was 174, and 55 for those exposed on the outside. In almost every case the number of germs obtained by both Hesse's apparatus and Petri dish exposures was greater inside than outside the stables. It was determined that the number of germs per liter of air could not be taken as an index of the sanitary surroundings. The dust caused by the feeding operation, the moving of bedding, currying, etc., have more to do with the number of germs which will be drawn into a Hesse tube or fall upon a Petri dish than has lack of ventilation. A box stall with sides and ceiling lined with matched lumber with no place for ventilation or the admission of food except a tightly closing door showed the fewest germs. The air became so foul in twenty-four to thirty hours that acute catarrh developed in the three different horses confined in it during the experiment.

A description of eighteen forms studied in detail is herewith appended:

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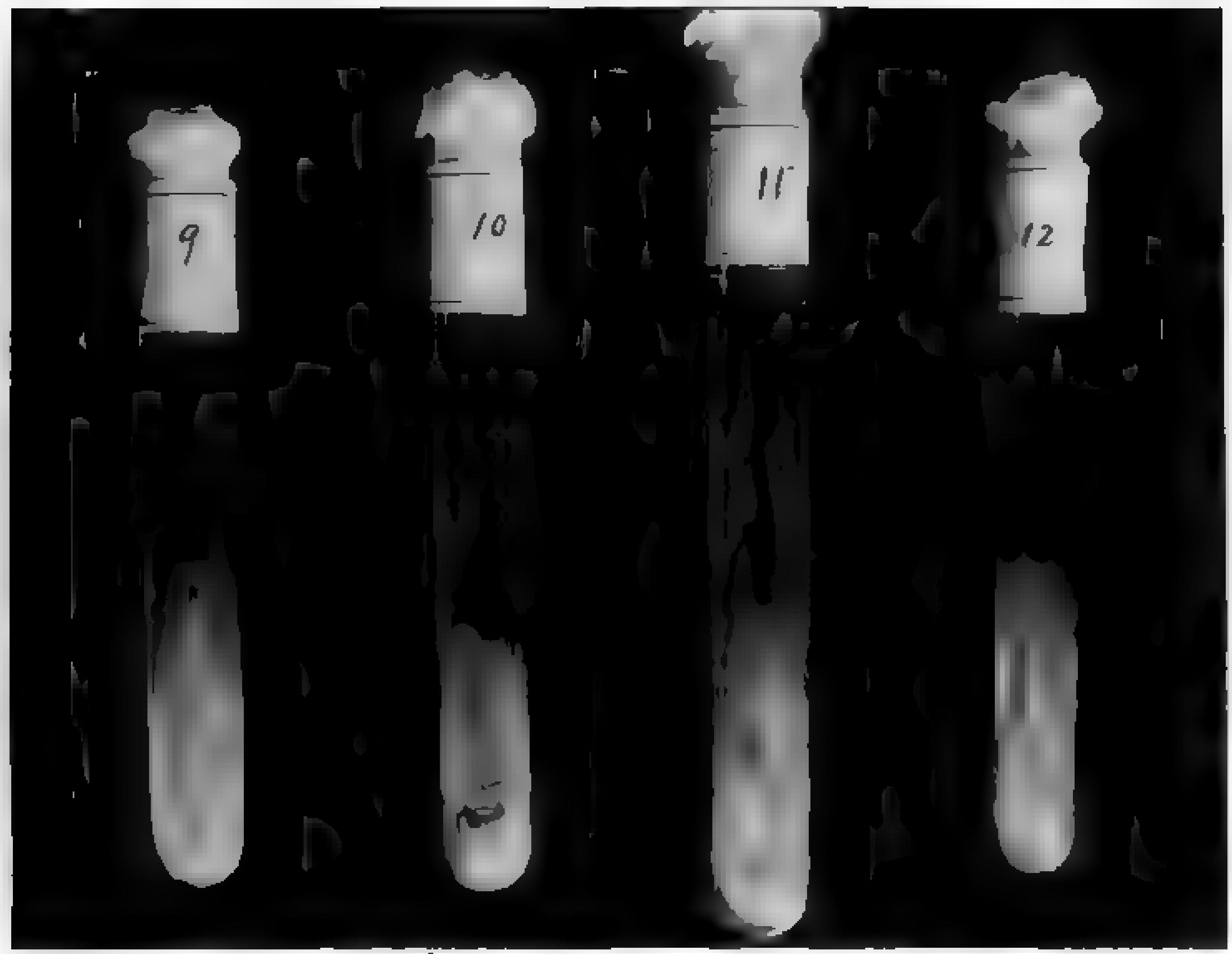
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DESCRIPTION OF FORMS OF BACTERIA OBTAINED FROM THE AIR IN STABLES.

FORM No. 1.

Obtained from the air of the stable in the horse barn at Purdue.

Morphology, a diplococcus 1 to 1.5$^{\mu}$ in diameter. Sometimes three or four are joined together.

Biological Characters. An ærobic, liquefying motile diplococcus. It grows in various media at room temperature. In Bouillon it produces turbidity and a white sediment is formed in bottom of the tube. In Gelatine Stick culture, growth occurs only at the surface; is not luxuriant, of a whitish color; producing a liquefaction which is covered with a white film. It grows at a temperature of 102° F. producing a whitish though not luxuriant growth. On Potato it gives a luxuriant reddish growth with a white growth intermingled. On Agar Plate the colonies

are white, slick, smooth surface, regular outline with a finely granular portion at the edge. On Agar Streak it gives a cream-colored, raised convoluted growth with folds running from the center to the edge. On Lactose Litmus Agar Plates the colonies were large. They produce no change in the litmus, showing that lac tic acid is not formed.

FORM No. 2.

Obtained from the air in the Purdue horse barn. The form is very abundant.

Morphology. A micrococcus 1 to 1.5$^{\mu}$ in diameter. It often occurs in masses of three or four.

Biological Characters. A liquefying, motile ærobic, micrococcus. In Bouillon it produces turbidity and forms a yellow ring on tube at surfaces of the liquid. A yellow precipitate collects in bottom of tube. On Potato it produces a raised, yellow, granular growth along the streak. In Gelatine Stick culture a yellowish growth occurs only on the surface which liquefies the gelatine. On Agar Plate the colonies are of a brownish color, of irregular outline and of a granular appearance. The colonies that grow on the surface are larger than those that grow on the bottom of the plate. This form grows at a temperature of 102° F.; giving a medium, irregular, white slick growth along the streak. On Agar Streak it forms a light yellowish, granular growth of irregular outline. On Lactose Litmus Agar plates the colonies are large and white. They produce a small amount of lactic acid.

FORM No. 3.

Obtained from the air in the Purdue cattle barn. Only a few colonies obtained.

Morphology. A bacillus 4$^{\mu}$ in length and about 1$^{\mu}$ in width. It occurs in short chains.

Biological Characters. A liquefying facultative anærobic, motile bacillus.

In Bouillon a white flacculent mass forms both on the surface and in the liquid. In Gelatine Stick cultures it produces a slight white growth along the puncture. It gives a light brownish, slick, luxuriant growth at a temperature of 102° F. It grows over the whole surface of the Agar and colors it brassy. On Potato it gives a raised, wrinkled, luxuriant, white powdery growth. On Agar Streak it forms a convoluted, raised, white growth, which is slightly granular at the edge. The colonies on Agar Plate, white with a pale spot in the center and are fringed at the edge. On Lactose Litmus Agar Plates the colonies are white, raised, wrinkled, with a granular growth around the edge. The litmus is changed slightly pink, showing a small production of lactic acid. The growth on this media is quite rapid.

FORM No. 4.

Obtained from the air in the Purdue horse barn. This form is quite abundant.

Morphology. A bacillus 3^{n} long and 1^{n} in width.

Biological Characters. A facultative anærobic bacillus.

In Bouillon it produces turbidity and a white sediment forms in bottom of tube. On Potato it forms a luxuriant, light brownish, raised growth. The growth at a temperature of 102° F. is very luxuriant over the whole surface of Agar and has a slick appearance. On Agar Streak it produces a greenish slick growth only along the streak. On Agar Plate, pale white colonies with a smooth outline are found, which later turned slightly green. The colonies which grow on the surface are larger than those on bottom of the plate. On Lactose Litmus Agar it produces no change in litmus, showing that this form does not produce lactic acid.

FORM No. 5.

Obtained from the air in the Purdue sheep barn.

Morphology. A diplococcus about 1^{n} in diameter.

Biological Characters. A liquefying, motile ærobic, non-spore forming diplococcus. It grows in various media at room temperature. In Bouillon it produces turbidity, and forms a white precipitate in the bottom of the tube. In Gelatine Stick a white growth forms only on the surface. The growth at a temperature of 102° F. is very slight, and is of a pale white or bluish color. On Potato a whitish growth forms over the whole surface of the Potato. On Agar Plate small white colonies, with smooth outline and smooth edges, are formed. They grew as luxuriantly on the bottom of plate as on the surface of the Agar. On Lactose Litmus Agar a portion of the litmus is colored pink, showing that a small quantity of lactic acid is produced.

FORM No. 6.

Obtained from the veterinary hospital when the ventilation was very poor.

Morphology. A bacillus from 2 to 3^{n} in length and $\frac{1}{2}^{n}$ in width.

Biological Characters. A liquefying ærobic, motile, a trembling motion, spore forming bacillus. It grows on various media at room temperature. In Bouillon it causes considerable turbidity, but forms only a slight sediment. On Potato it produces a yellowish, raised, wrinkled growth. In Gelatine Stick it liquefies the gelatine on the surface and forms a white scum over the part that is liquefied.*

* See Plate No. 10.

On Agar Plate it forms small white irregular colonies which are fringed at the edge. The growth at a temperature of 102° F. is white, smooth, very luxuriant, and grows over whole surface of Agar. On Lactose Litmus Agar Plate the colonies are white and produce a slight change in the litmus, showing the production of a small amount of lactic acid.

FORM No. 7.

Obtained from the veterinary hospital.

Morphology. A sarcena about $1\frac{1}{2}^{u}$ across.

Biological Characters. A non-liquefying ærobic sarcena. It grows in most media at room temperature. In Bouillon it produces turbidity and forms a white sediment in bottom of tube. On Gelatine Stick cultures a very slight yellow growth forms on the surface. On Agar Streak it gives a slick yellowish growth. The growth extends over surface of Agar, and has an irregular outline.* On Potato it forms a deep yellow, slick growth along the streak. The growth at the temperature of 102° F. was very slight, and has an irregular outline. On Agar Plate it forms small, yellow granular colonies with a smooth outline. The colonies that grow on the bottom of the plate are transparent at the edges and granular in the center. On Lactose Litmus Agar Plate small white colonies are formed, which produce a slight change in the litmus showing the formation of lactic acid.

FORM No. 8.

Obtained from the veterinary hospital. Only a single species was obtained.

Morphology. A short round bacillus 2^{u} long and 1^{u} broad. It occurs singly.

Biological Characters. A non-liquefying, non-spore forming motile bacillus. The growth on usual media at the room temperature is very slight. In Bouillon it produces slight turbidity and forms a brownish sediment in bottom of tube. It does not grow on potato. In Gelatine Stick it produces a very slight, transparent growth. The growth at a temperature of 102° F. is very slight, and is of a pale white color, with an irregular outline. On Agar Plate it forms small, white or transparent colonies with a smooth edge. Lactose Litmus Agar Plate, it produces no change in litmus, showing the production of no lactic acid. In a hydrogen atmosphere this form grows very luxuriant. The growth is white granular and extends over surface of Agar.

* Plate.

FORM No. 9.

Obtained from the air in the veterinary hospital.

Morphology. A bacillus 3^{n} long and $\frac{3}{4}^{n}$ broad. It occurs singly.

Biological Characters. A non-liquefying, faculative anærobic, actively motile-spore-forming bacillus. In Bouillon it produces turbidity and forms a slight, whitish sediment in the bottom of the tube. On Potato it forms a white, smooth growth. In Gelatine Stick cultures it forms a small cup-shape growth on sur, face. It grows slightly along stick and did not liquefy the gelatine. On Agar Streak it forms a slick white growth over the whole surface of Agar. On Agar Plate white, irregular, finely granular colonies are formed. It grows both on surface of Agar and on bottom of plate. The growth at a temperature of 102° F. is slick, white, luxuriant and extends over surface of Agar. On Lactose Litmus Agar Plate it forms pearly white colonies, which produce lactic acid in considerable quantity.

FORM No. 10.

Obtained from the air in the veterinary hospital.

Morphology. A long slender bacillus with square ends. It occurs united in chains of two or three cells. Length 4^{n}, width 1^{n}.

Biological Characters. A liquefying, non-motile, spore-forming, facultative, anærobic bacillus. In Bouillon it forms a white sediment on bottom of tube and a white film over surface. On Agar Streak it produces a brownish slick growth with an irregular outline and a white portion on the edge.* On Potato luxuriant white, raised, wrinkled growth appears. In Gelatine Stick culture it rapidly liquefies the gelatine and forms a white scum on the surface. On Agar Plate it develops into white colonies with a smooth outline. They grow both on surface and on the bottom of the plate. The growth at temperature of 102° F. is white and not luxuriant. On Lactose Litmus Agar Plates no change is produced, showing that lactic acid is not formed.

FORM No. 11.

Obtained from the air in the veterinary hospital. This form is quite abundant.

Morphology. A short, thick bacillus. It often occurs united in chain of two cells. Length 3^{n}, width $1\frac{1}{2}^{n}$.

Biological Characters. A liquefying, non-motile, facultative, anærobic, spore-forming bacillus. In Bouillon it forms a white sediment in bottom of tube and a

* See Plate.

white scum over the surface. On Agar Streak it produces a white, raised, folded growth. On Agar Plate it forms smooth white colonies with an even outline. The colonies grow both on bottom of plate and on surface of Agar. In Gelatine Stick culture it liquefies the gelatine in a dish-shape growth. It grows along the stick and liquefies the gelatine. On Potato it forms a raised, wrinkled, white growth.* On Lactose Litmus Agar small white colonies grow, which produce lactic acid.

FORM No. 12.

Obtained from the air in Mrs. Morley's barn.

Morphology. A small bacillus 1 to 2ᵘ in length and ½ᵘ in width. It occurs singly.

Biological Characters. A liquefying, actively motile, facultative, anærobic, non-spore-forming bacillus. In Bouillon it produces turbidity in a short time and forms a white sediment in bottom of tube, On Potato it gives a reddish growth extending over surface. On Agar Streak the growth is of a cream color and not very luxuriant. The growth presented an irregular outline and was lined with small white dots near the edge. It produces a white growth all over the surface of Agar at a temperature of 102° F. In Gelatine Stick culture it liquefies the gelatine in a saucer-shape growth, and it grows slightly along the stick. On Agar Plate it forms white, granular colonies with a smooth outline. It grows mostly on the surface of the Agar. On Lactose Litmus Agar large round colonies grow. It produces no change in litmus, showing no lactic acid.

FORM No 13.

Obtained from the air in the veterinary hospital.

Morphology. A short bacillus with round ends. 2½ᵘ in length and 1ᵘ in width. It occurs in short chains.

Biological characters. A liquefying non-motile, spore forming, facultative anærobic bacillus. In Bouillon it produces turbidity and forms a white sediment in bottom of tube. On Agar Streak it forms a light yellow smooth growth with an irregular outline. The growth was near the edge and was of a whiter color than the center. On potato it forms a slick, raised, cream-colored growth along the streak. In Gelatine Stick culture it liquefies the gelatine and forms a white scum over the surface. The growth at temperature of 102° F. is slight and of a white color. On Agar Plate it produces large pearly white colonies with a smooth outline, which later turned to a brownish color. On Lactose Litmus Agar it forms white colonies which do not produce lactic acid. (See plate.)

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* See Plate.

FORM No. 14.

Obtained from the air in the veterinary hospital.

Morphology. A diplococcus $\frac{1}{2}^{\mu}$ in diameter.

Biological Characters. A non-liquefying ærobic, probably motile diplococcus. In Bouillon it produces turbidity and a light greenish sediment forms in bottom of tube. A white scum forms on tube at surface of liquid. On potato it forms a greenish yellow growth along the streak. The growth on potato is not luxuriant and has a granular appearance. The form does not grow very luxuriant at a temperature of 102° F. In Gelatine Stick culture it forms a dish shape white growth and does not liquefy the gelatine. On Agar Streak a greenish yellow, slick growth with a smooth outline appears. On Agar Plate it forms yellowish green colonies with a ragged outline. The colonies present a granular appearance with a light or transparent ring about half way between the edge and the center. The colonies that grew on the surface are larger than those that grew on the bottom of plate. On Lactose Litmus Agar it forms large white colonies which do not produce lactic acid. (See plate.)

FORM No. 15.

Red yeast.

Obtained from the air in Professor Troop's barn.

Morphology. It appears as oval shaped cells 3 to 4^{μ} long and $\frac{1}{2}^{\mu}$ broad.

Biological Characters. Aerobic. In Bouillon it forms a reddish sediment in bottom of tube. On Potato it produces a pinkish though not luxuriant growth. On Ager Streak it forms a pinkish slick growth. It does not grow at the temperature of 102° F. In Gelatine Stick culture it grows only on surface and does not liquefy the gelatine. (See plate.)

FORM No. 16.

Obtained from the air in Professor Troop's barn. Only one colony was obtained.

Morphology. It appears as tetrads, and is composed of four germs in a group; it is about $2\frac{1}{2}^{\mu}$ across.

Biological Characters. A non-liquefying, facultative anærobic motile, non-spore forming tetrade. In Bouillon it produces turbidity and forms a white sediment in bottom of tube. On Agar Streak it forms a white branched growth. On Potato the growth is slow, does not show the branched appearance, and has a granular appearance. In Gelatine Stick culture it forms an irregular dish shape growth.

It grows slightly along the stick. It does not grow at a temperature of 102° F. On Agar Plate it forms small pearly white colonies with a smooth outline and a white spot in center. It grows as well on bottom of dish as on surface of agar. On Lactose Litmus Agar it forms branched white colonies. It produces no lactic acid. (See plate.)

FORM No. 17.

Obtained from Gregory & Dobbins' livery barn. This form is fairly abundant.

Morphology. A diplococcus $\frac{3}{4}^{n}$ in diameter.

Biological Characters. A non-liquefying, non-motile ærobic diplococcus. In Bouillon it produces turbidity and forms a white sediment in the bottom of tube. A white ring forms on tube at surface of liquid. On Agar Streak it forms a slick, red colored growth along streak. In Gelatine Stick culture it grows only on surface, is of a pink color and does not liquefy the gelatine. On Agar Plate it forms small white colonies. The growth is very slow. On Lactose Litmus Agar no change was produced in litmus, showing no lactic acid. It does not grow on Potato.

FORM No. 18.

Obtained from Godman's livery barn.

Morphology. A small micrococcus about $\frac{1}{2}^{n}$ in diameter.

Biological Characters. A non-liquefying, non-motile, ærobic micrococcus. In Bouillon it produces considerable turbidity and forms a white ring on tube at surface of liquid; it also forms a white precipitate in bottom of tube. On Potato it forms a raised granular cream-colored growth along streak. In Gelatine Stick it produces a white convoluted growth on surface, and does not liquefy the gelatine. On Agar Streak it forms a milk white growth with irregular outline. On Agar Plate it produces pale white luxuriant colonies with a smooth outline. On Lactose Litmus Agar the colonies are small and white, producing considerable lactic acid.

Have the Common Yeasts Pathogenic Properties?—An Experimental Study. By Katherine E. Golden.

Yeasts have always been considered as purely saprophytic organisms, and not supposed to be parasitic in any sense; but, in the light of some recent experiments, this classification would seem to need reconsideration. These experiments indicate not only that some yeasts are parasitic, but that they are also pathogenic. These results are not at all at variance with developments made in the study of other organisms, as many bacteria which at first were supposed to be saprophytic

have developed parasitic properties; this being brought about through a course of adaptation, which has enabled them to exist under the changed conditions. There are other bacteria possessing pathogenic properties which can be treated in such a manner as to cause them to lose their virulency, among these a notable one being anthrax, which when carried through a course of gelatine cultures is no longer pathogenic. The pathogenic properties may be restored, however, by appropriate treatment, such as cultivation at the body temperature in specially prepared media. Of course, the conditions for a saprophytic mode of life are more generally met with than those for the development of parasitic life, so that it is presumable that most organisms become adapted to them.

About twenty years ago yeast was used in water to spray plants in greenhouses for the purpose of getting rid of insect pests.* This treatment was based upon the belief that the yeast entered the body of the insect and produced a growth which was fatal. As pure yeast was not used, and as yeasts usually have associated with them bacteria and molds, the use of yeast for such purposes is not conclusive in proving it to be pathogenic.

Somewhat later a yeast, S. Allii, was grown on the bulbs of onions, and caused them to rot by reducing them to a gelatinous condition,† during which time a powerful odor was emitted by them. Bacteria were also found in conjunction with the yeast in the onions.

In recent years, since accurate methods have been devised for the separation of the various species and varieties of yeasts, a more definite knowledge has been obtained of their properties. It has been determined that while most of them possess the property of exciting alcoholic fermentation, that, aside from this, they differ widely in the formation of other products that accompany the fermentation. For example, two species that were found on the fruit of *Ilex aquifolium*, though having the same habitat, gave different products, the one (*S. ilicis* Grönlund) gave a disagreeable, bitter taste to wort, while the other (*S. aquifolii* Grönlund) gave a disagreeable, sweet taste. Of two ellipsoid species studied by Will, the one gave a rough, bitter after-taste, while the other imparted a disagreeable, aromatic taste during the fermentation, and a bitter, astringent after-taste to wort. Then of two species studied by Hansen, one (*S. Pastorianus* I.) gave a disagreeable, bitter taste and unpleasant odor to wort, while the other (*S. anomalous*) gave an ethereal, fruity odor. One might go on at length giving examples of the differences in the products of yeasts, but from what has been given, it can be seen that the products differ widely, and that it is highly probable that some of these

*Hagen, H. A., "Nature," Vol. XXI, p. 611. 1880, April.
†Sorokin, N., Jour. Roy. Micr. Soc., 1889, Pt. I.

various products might be of a toxic character, and also highly probable that if these yeasts were growing vigorously and metabolic activity high, these toxic substances might cause injurious effects either locally or constitutionally in the animal body.

A somewhat common opinion in regard to the yeasts is that when taken into the stomach in bread not cooked sufficiently they set up a fermentation, generate gas, and thus cause great discomfort, though the same kind of gas when taken in soda water seems to have a rather soothing effect. Then this opinion does not seem to prevail in regard to the use of beer or other fermented drinks, though there is no question in regard to the presence or vitality of the yeasts in these beverages.

To determine the effect of yeasts taken into the stomach, two rabbits were placed in a cage in the laboratory where they could be observed conveniently. They were kept over night without any food, and in the morning were given two compressed yeast cakes. These they refused to eat, presumably from their behaviour objecting to the odor. The yeast was then smeared on sugar beet, which they ate. No apparent result followed. After two days about two grams of a pure culture yeast were smeared on sugar beet, which was fed them, after which a week was allowed to intervene. Then, at intervals of two days, each rabbit was given a dry yeast cake, until each one had eaten five cakes. The dry cakes were eaten with avidity, being preferred to the sugar beets, their usual food. At the end of this treatment the rabbits were still healthy, had apparently experienced no discomfort from the unusual addition to their diet, and showed no symptoms of disease. After two days one was chloroformed and then examined, to determine if there were any internal lesions. There proved to be none, all the organs being in their normal, healthy condition. During this examination inoculations were made from the various parts of the intestinal tract—cardiac portion of stomach, pyloric portion of stomach, duodenum, jejunum, ileum, caecum, anterior colon, posterior colon—into sterilized bouillon and wort.

During the time the experiment was in progress, inoculations were made daily into sterilized bouillon and wort from the discarded portions of food which had passed through the intestinal tract. Out of those cultures in wort seven developed yeast alone, seven developed yeast and mould, and two developed mould alone. In conjunction with two of the yeasts was a red yeast which occurs in the air in the laboratory. All of the cultures in bouillon, but one, had a bacterium, resembling the "thrix" forms. An inoculation into bouillon and wort was made in each case from the same material, the bouillon being neutral, the wort acid. The yeasts and mould developed in the wort, but not in the bouillon, whereas,

the bacterium developed in the bouillon, but did not appear in the wort. The organisms in both media were very slow in developing, the first appearance of growth being in about five days, some taking even six and seven days; and in the case of the yeast the fermentation was weak. But in most cases the fermentation lasted for over three weeks.

To test the effect of yeast when introduced into the circulation of animals, pure culture yeasts were used, one separated from a moist yeast cake, one from a dry yeast cake, and the third a wild yeast obtained from the surface of plum. Ten drops from a four days' culture in wort of each yeast were injected into the posterior branch of the main vessel of the ear of three rabbits. These were kept under constant observation, but showed no ill effects from the introduction of the yeast.

Another test was then made upon two different rabbits, and upon two guinea pigs. The yeasts used for the rabbits were a wild one from the surface of persimmon, and one from a moist yeast cake, but a different yeast from the one used in the first experiment. The yeasts used for the guinea pigs were one from the surface of grape, and one from a moist yeast cake, also different from the two previous yeasts. The inoculations in the rabbits were in the vessel of the ear, but those of the guinea pigs were intra-peritoneal. The following day the guinea pigs were slightly sore in the region of the puncture of the hypodermic needle, but that wore off in a short time, and no other ill effects were experienced by any of the animals.

For the next experiment twenty-two different yeasts were grown at the body temperature (37½° C.) in order to select from them the ones growing most vigorously. These proved to be two wild ones, one from apple, the other from guava, and two cultivated ones, one from beer, and one from a moist yeast cake. One of the yeasts was injected into the ear of a rabbit, a second into the ear of a guinea-pig, while the third and fourth were subcutaneous, into the abdominal wall of guinea-pigs. No ill effects followed the inoculations.

After two days sterilized bouillon and wort were inoculated with blood from the ear of each animal, but in all cases remained sterile. In one tube of wort, in which a large drop of blood had been placed, a few dead yeast cells were found, but no growth took place, indicating that the yeast must have been destroyed in a short time.

The results of the experiments agree in the main with those of Neumayer,* except that he claims that an injury to the animal may always be expected if a fermentable substance be taken at the time the yeasts are. He also claims that when yeasts are grown at a high temperature, abnormal fermentation products

* Neumayer, J. Centralb. für Bakt. und Parasitenk., Bd. XIII, 1893, p. 611.

are formed which may be injurious, this being true for both wild and cultivated yeasts, but that the normal products of fermentation or the multiplication of the yeast cells are not injurious.

Busse* has found a yeast which causes a chronic pyæmia. From its resemblance to Actinomycosis he gave the disease the name Saccharomycosis hominis. The course of the disease, as outlined, is that the yeast falling upon the body increases and causes a local change, this eventually leading to formation of pus and general inflammation. The yeast causes the death of white mice, the blood of which is found to contain numerous yeast cells.

Rabinowitsch,† out of fifty different varieties of yeasts, obtained seven pathogenic ones, which, when injected subcutaneously into mice, rabbits and guinea-pigs, caused their death. It is claimed in this case that the fatalities were due to the rapid multiplication of the yeast cells in the body, and not to any products of fermentation. The yeasts seem to be different from the pathogenic ones of other observers.

The only reasonable conclusion which can be drawn in regard to these varying results is that different species or varieties of yeast were used, these different yeasts having very different products. The writer used only common yeasts, such as are being taken into the system through various sources, from time to time. Though the pressed yeasts, when used in bread, are killed, the products are taken into the system, and all the others used would be taken into the system alive, as they occurred on the skin of fruits and in beer.

The first set of experiments indicate that yeast, when taken into the stomach of rabbits, causes neither discomfort nor lesions in any organ, even when a fermentable substance be eaten at the same time. They also indicate that certain organisms—yeasts, bacteria and moulds—can pass through the intestinal tract without being killed, though from the slowness of growth and the weakness of the fermentation, their vigor must be somewhat impaired.

The second set of experiments indicate that of the common yeasts those used possessed no toxic properties for rabbits or guinea-pigs, neither did they multiply when introduced into the animal body, and in the case of four of them, they must have been destroyed within 48 hours, though these same yeasts were very vigorous at the same temperature outside the body.

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* Busse. Centralb. für Bakt. und Parasitenk., Bd. XVII, 1895, p. 719.

† Rabinowitsch, L. Centralb. für Bakt. und Parasitenk., Bd. XVIII, 1 Abt., 1895, p. 580.

Exceptional Growth of a Wild Rose. By Stanley Coulter.

While botanizing at Eagle Lake, Indiana, the past summer, my attention was attracted by the peculiar growth of a wild rose. The bush arose from near the center of an oak stump, which was some two or three feet in diameter. The wood of the stump was extremely hard, and showed no signs of decay so far as could be determined by a large knife. No cracks of any character, large or small, were observable upon the summit of the stump or along its sides. The three stems of the bush seemed at first glance to emerge, each from a specially prepared hole, which it fitted with extreme accuracy, so closely indeed as to prevent movement in any direction. My first impression was that it was a skillfully executed trick. Further examination, however, showed that at the point of emergence from the stump each stem showed a well marked intumescence, evidently the result of arrested growth currents. These swellings resembling exactly those found at the bases of branches in girdled trees. The bush itself was some two feet high, and when first visited was in full bloom, bearing fourteen flowers. It continued flowering throughout the season, and later set seed well. The foliage leaves, while perhaps not so large as in bushes of corresponding size growing in the earth, were in all other particulars perfectly normal. Evidently the plant was several years old, and that it had had a vigorous growth was sufficiently evidenced by the intumescences upon the stem, by its prolific flowering and abundant seed setting. A careful examination of the stump at its base showed no crevices in which seeds could find lodgment. It was very plain that in some way, on the surface of this apparently solid oak stump, the bush had succeeded in finding the requisites for a successful growth.

In May, 1897, I again visited the stump and found the bush making a vigorous growth. At this time, however, I observed some wood peckers at work on the stumps of some newly sawed oaks. Examining the stumps I found many in which holes had been drilled by this bird. I mention this as a possible explanation of the way in which the seeds obtained lodgment. It does not, however, account for such a vigorous growth under such apparently adverse circumstances. The stump, so far as could be determined, was perfectly solid, with not even a marginal rim of decay, although in one or two places the bark had fallen away. How did the bush on the summit of a solid oak stump, four feet from the ground, obtain sufficient moisture? Its stems were so securely fixed in the surrounding wood that the most vigorous efforts failed to produce movement in any direction. In the absence of decayed material, what was the source of food supply? I examined the plant many times, and have not been able to answer these questions

to my own satisfaction. It has been suggested that the growth was from a crack which had gathered soil. A mere glance negatives the suggestion. Again it has been said that the stump, though apparently sound, is really decayed. This, of course, is possible, but in no part of the stump to a depth of three inches was there the slightest trace of decay that could be detected.

To my mind it stands as the title indicates, as an exceptional growth of a wild rose.

A Revision of the Species of the Genus Plantago Occurring Within the United States. By Alida Mabel Cunningham.[1]

The genus Plantago of Tournefort under rule 2 of the Madison code is now to be referred to Linnæus, Sp. Pl. 112 (1753). The description of the genus found in the 6th edition of Gray's Manual is so complete that it is here quoted without change.

The purpose of the following study was a revision of the various species of this genus, based upon seed characters because of the belief that such characters were most likely to be constant and of diagnostic value. The results obtained by this study have led to a confirmation of these views, and it is believed that an extension of studies of this character would be of high value.

The material examined was that contained in the herbaria of the United States Department of Agriculture, the University of Minnesota, Purdue University and the private herbarium of Dr. John M. Coulter. I extend my thanks to the gentleman owning or in charge of these collections for their kindness in permitting me to retain the material for the time needed, and to Mr. E. B. Uline for some original descriptions. I am also deeply indebted to Dr. Stanley Coulter for his trouble in procuring the material examined, and for his many valuable suggestions in the study of the subject.

The results show that the genus may be broken up into three sections, clearly separated by seed characters, as follows:

I. Seeds oval in cross section.

P. cordata, major, Rugelii, eriopoda, decipiens, maritima, Tweedyi.

II. Seeds more or less anther shape in cross section.

P. lanceolata, Patagonica, hirtella, Virginica, rubra and minima.

III. Seeds irregularly lobed in cross section.

P. elongata, heterophylla and Bigelovii.

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[1]Plates 1-20, photographs of the various species, which were intended to accompany this article, are omitted because of lack of funds.

The differences in present arrangement, resulting from this, are as follows: lanceolata and Patagonica are placed in section two, instead of one; while elongata and heterophylla are placed in a third section.

In the material examined it has been found necessary to establish two new species, P. rubra and P. minima, which was done somewhat reluctantly.

It has been found impossible to follow, in all particulars, the nomenclature in the "List of Pteridophyta and Spermatophyta, Botanical Club, A. A. A. S." There seems to be no good reason why varieties aristata and gnaphalioides of Patagonica, and longifolia of Virginica should be raised to specific rank. Certainly if seed characters have any value in determining specific rank, the reason would seem positive why they should still be considered as varieties.

P. decipiens, on the other hand, is not to be included under P. maritima, being clearly separable from it, as indicated below.

The original description of P. Tweedyi was not secured. A single specimen was examined, and on account of its seed characters was placed in section 1. Judgment as to exact relationship must be suspended until more specimens and the original description can be obtained.

No specimens of P. sparsiflora were examined, but from the description given in "Chapman's Flora of the Southern States," it probably belongs in section 2.

All specimens of P. major, var. Asiatica, were referred to either P. major or P. Rugelii.

P. media is mentioned in the "List of Pteridophyta and Spermatophyta of the United States," but is not described in "Gray's Manual," "Coulter's Rocky Mountain Botany" or "Chapman's Flora of the Southern States." The specimens examined were from Europe, and are not, therefore, included in this work.

ANALYSIS OF THE SPECIES OF PLANTAGO.

§1. Flowers perfect; stamens, 4; corolla not closed over fruit; seeds oval in cross section.

* Leaves broadly ovate, strongly veined.

† Leaves and scape glabrous, or slightly hairy; seeds light brown. P. cordata.

†† Leaves and scape glabrous, or slightly hairy; seeds angled, black.

‡ Capsule ovoid, circumscissile at the middle, 8–18 seeded; seeds $\frac{3}{4}$ mm. x $\frac{3}{8}$ mm. P. major.

‡‡ Capsule conical, circumscissile below the middle, 4–9 seeded; seeds $1\frac{5}{8}$ mm. x $\frac{3}{4}$ mm. P. Rugelii.

** Leaves lanceolate to linear, not strongly veined, thick and rough.

† Leaves smooth; scape smooth or slightly hairy. **P. eriopoda.**

†† Leaves and scape slightly pubescent.

‡ Capsule circumscissile at the middle, seeds black; hilum not at centre of seed. **P. decipiens.**

‡‡ Capsule circumscissile below the middle; seeds dark brown; hilum at centre of seed. **P. maritima.**

*** Leaves lanceolate, smooth; capsule circumscissile below the middle; seed. light brown. **P. Tweedyi.**

§2. Flowers various; stamens, 4; seeds more or less anther shape in cross section.

* Corolla not closed over fruit; leaves lanceolate to linear.

† Leaves lanceolate; scape grooved, slightly hairy; seeds yellow, surface smooth. **P. lanceolata.**

†† Leaves linear; scape not grooved, densely hairy.

‡ Capsule twice as long as calyx: seeds yellow, surface smooth. **P. minima.**

‡‡ Capsule slightly longer than calyx; seeds dark brown, surface pitted. **P. Patagonica.**

** Corolla closed over fruit; leaves ovate to lanceolate.

† Capsule oblong, circumscissile below the middle; seeds black. **P. hirtella.**

†† Capsule ovoid, circumscissile at the middle; seeds yellow. **P. Virginica.**

††† Capsule oblong, circumscissile below the middle; seeds dark red. **P. rubra.**

§3. Flowers polygamo-dioecious; stamens, 2; corolla closed over fruit; seeds irregularly lobed in cross section.

* Leaves linear to filiform, smooth or minutely pubescent, scape very slender.

† Capsule ovoid, circumscissile at the middle; 4 seeded; seeds $1\frac{3}{8}$ mm. x $\frac{1}{2}$ mm., **P. elongata.**

†† Capsule conical, circumscissile below the middle; 10–28 seeded; seeds $\frac{5}{8}$ mm. x $\frac{1}{4}$ mm., **P. heterophylla.**

††† Capsule conical, circumscissile below the middle, 5 or 6 seeded; seed, $1\frac{1}{4}$ mm. x $\frac{1}{2}$ mm., **P. Bigelovii.**

ANALYSIS OF THE SPECIES OF PLANTAGO, ACCORDING TO SEED CHARACTERS.

§1. Seeds oval in cross section.	
† Black, surface glossy.	
‡ Size, $\frac{3}{4}$ mm. x $\frac{3}{8}$ mm.,	P. major.
‡‡ Size, $1\frac{5}{8}$ mm. x $\frac{3}{4}$ mm.,	P. Rugelii.
†† Black, surface dull.	
‡ Hilum at centre of seed,	P. eriopoda.
‡‡ Hilum not at centre of seed,	P. decipiens.
††† Light-brown, surface dull.	
‡ Size, 6 mm. x 3 mm.,	P. cordata.
‡‡ Size, $1\frac{1}{2}$ mm. x $\frac{5}{8}$ mm.,	P. Tweedyi.
†††† Dark-brown, surface dull,	P. maritima.
§2. Seeds more or less anther shape in cross section.	
† Yellow, surface smooth.	
‡ Size, $2\frac{1}{4}$ mm. x $\frac{3}{4}$ mm.,	P. minima.
‡‡ Size, 5 mm. x $1\frac{2}{3}$ mm.,	P. lanceolata.
†† Yellow, surface striated; size, $1\frac{1}{4}$ mm. x $\frac{7}{8}$ mm.,	P. Virginica.
††† Dark brown,	P. Patagonica.
†††† Black,	P. hirtella.
††††† Red,	P. rubra.
§3. Seeds irregular in cross section.	
† Longitudinal section deeply lobed.	
‡ Size, $1\frac{3}{8}$ mm. x $\frac{1}{2}$ mm.,	P. elongata.
‡‡ Size, $\frac{5}{8}$ mm. x $\frac{1}{4}$ mm.,	P. heterophylla.
†† Longitudinal section regular in outline,	P. Bigelovii.

Plantago, Tourn. Plantain.

Calyx of four imbricated persistent sepals, mostly with dry membranaceous margins. Corolla salver form or rotate, withering on the pod, the border four-parted, or rarely two, in all or some flowers with long and weak exserted filaments, and fugacious two-celled anthers. Ovary two (or in No. 8, falsely, three-four) celled, with one-several ovules in each cell. Style and long hairy stigma single, filiform. Capsule two-celled, two-several seeded, opening transversely, so that the top falls off like a lid and the loose partition (which bears the peltate seeds) falls away. Embryo straight, in fleshy albumen. Leaves ribbed. Flowers whitish, small, in a bracted spike or head, raised on a naked scape.

§1. Flowers perfect; stamens four; corolla not closed over fruit; seeds oval in cross section.

* Leaves broadly ovate, strongly veined; petioles long, flat and channelled.

† Leaves and scape glabrous; seeds light brown.

1. P. cordata Lam.—150 mm. to 300 mm. high; leaves round ovate, glabrous, seven or nine veined, more or less cordate at the base, margins entire or slightly toothed; petioles smooth, long, flat, channelled; spike long, cylindrical, looosely flowered, lower ones scattered with round, ovate bracts; scape smooth, 150 mm. to 450 mm. long; corolla longer than the calyx (Plate I); capsule twice as long as the calyx, two-celled, from two to four-seeded; ripe seeds light brown, surface dull, minutely striate longitudinally, cross section oval (Plate A, Fig. 1); longitudinal section oval (Plate D, Fig. 1); size 6 mm. x 3 mm.; hilum at center of seed.

Found in low ground and along streams from New York to Missouri and southward.

Specimens examined: Chicago, Illinois (Brendol, National Herbarium); Allenton, Missouri (G. W. Letterman, 1882, National Herbarium); Winnetka, Illinois (Aiton Collection, May 10, 1891, Herbarium of the University of Minnesota); Alma, Michigan (C. A. Davis, May 29, 1893, Herbarium of the University of Minnesota; Alexandria, Virginia (Prof. Comstock, 1881, National Herbarium); Tippecanoe County, Indiana (Hussey, Herbarium of Purdue University); Hubbardston, Michigan (C. F. Wheeler, May, 1876, Herbarium of J. M. Coulter).

†† Leaves and scape glabrous or slightly hairy; seeds black.

2. P. major L.—75 mm. to 350 mm. high; leaves broadly ovate or oblong, smooth or slightly hairy, five or seven nerved, margins entire or slightly toothed, abruptly narrowed into a flat, channelled petiole; spike 47½ mm. to 200 mm. long, cylindrical, obtuse at apex, densely flowered; bracts ovate; scape 125 mm. to 400 mm. long, smooth or sparingly hairy, round; sepals round, ovate, obtuse, not carinate (Plate 2); capsule short, ovoid, slightly longer than the calyx, circumcissile at the middle, eight-18-seeded; ripe seeds black, angled, surface glossy, minutely granular, granules irregularly arranged, cross section oval (Plate A, Fig. 2); longitudinal section oval (Plate D, Fig. 2); size ¾ mm. x ⅜ mm.; hilum at center of seed.

An exceptional form of P. major found at St. Paul, Minnesota (Herbarium of the University of Minnesota), has a leafy spike. Just below each seed is a leaf. These leaves are of considerable size at the base of the spike, but become gradually smaller toward the apex.

Grows in moist places from Delaware to California and northward.

Specimens examined: Vegas Valley, Nevada (Coville and Funston, 1891, 390, alt. 1,065 meters, National Herbarium); Sleepy Eye, Minnesota (E. P. Sheldon, July, 1891, Herbarium of the University of Minnesota); California (C. R. Orcutt, June, 1889, National Herbarium); Shore of Lake Superior, Minnesota (F. F. Wood, 1891, Herbarium of the University of Minnesota); Ogden, Utah (G. W. Letterman, July 29, 1885, National Herbarium); Nicollett's Northwestern Expedition (C. A. Geyer, July 24, 1839, National Herbarium); Minnesota (F. F. Wood, 1891, National Herbarium); Centreville, Delaware (Commons, August 3, 1878, National Herbarium); Mishawaka, Indiana (E. B. Uline, July, 1891, Herbarium of J. M. Coulter); Elliston, Montana (F. D. Kelsey, Herbarium of J. M. Coulter); Georgetown, Colorado (H. N. Patterson, July 11, 1885, Herbarium of J. M. Coulter); Oregon (P. major, var. Asiatica, T. J. Howell, May, 1880, National Herbarium).

3. P. Rugelii Decaisne:—125 mm. to 300 mm. high; leaves broadly ovate or oblong, smooth or sparingly hairy, five or seven nerved, margin entire or toothed; petioles flat, channelled; spike, 75 mm. to 250 mm. long, cylindrical, loosely flowered, acute at apex; bracts acute; scape, 125 mm. to 450 mm. long, smooth or sparingly hairy; sepals oblong, acute, carinate (Plate 3); capsule conical, twice as long as calyx, circumscissile below the middle, 4–9 seeded: ripe seeds black, angled, surface glossy, minutely granular, granules irregularly arranged, cross section oval (Plate A, Fig. 3); longitudinal section oval (Plate D, Fig. 3); size 1⅝ mm. x ¾ mm.; hilum at center of seed.

Grows in moist soil from Vermont to Minnesota and south to Texas and Georgia.

Specimens examined: Peoria, Illinois (McDonald, Aug. 4, 1893, Herbarium of the University of Minnesota); Allenton, Missouri (G. W. Letterman, 1882, National Herbarium); Camden, New Jersey (I. C. Martindale, 1878, National Herbarium); Harrisburg, Pennsylvania (Sandberg Collection, Aug. 14, 1888, Herbarium of the University of Minnesota); Michigan (C. F. Wheeler, July 23, 1890, National Herbarium); Minneapolis, Minnesota (C. L. H., June 20, 1876, Herbarium of the University of Minnesota); Blue Earth Co., Minnesota (Sandberg Collection, Herbarium of the University of Minnesota); Jordan, Scott Co., Minnesota (C. A. Ballard, June, 1891, Herbarium of the University of Minnesota); Cannon Falls, Minnesota (P. major, J. H. Sandberg, Aug., 1881, Herbarium of the University of Minnesota); Charlotte, Vermont (C. G. Pringle, Sept. 8, 1878, National Herbarium); Belle Isle, Detroit, Michigan (O. A. Farwell, July 3, 1893, Herbarium of the University of Minnesota); Centreville, Delaware (Commons, Sept. 23, 1878, National Herbarium); Indian Territory (Dr. Palmer, 1868,

National Herbarium); Glencoe, Minnesota (P. major, T. J. M., Aug. 1, 1890, Herbarium of the University of Minnesota); Cambridge, Massachusetts (Kellerman, July 5, 1878, Herbarium of J. M. Coulter).

Between P. major and P. Rugelii are found a number of intermediate forms which are difficult to classify except in fruiting stage.

** Leaves lanceolate to linear, not strongly veined, thick and rough.

† Leaves smooth, scape smooth or slightly hairy.

4. P. eriopoda Torr.—50 mm. to 150 mm. high; usually having a mass of yellowish wool at the base; leaves ovate to lanceolate, thick, rough, three to seven nerved, obtusely or acutely pointed, tapering gradually into a short, margined petiole, margins entire; spike 25 mm. to 125 mm. long, cylindrical, densely or loosely flowered; scape 100 mm. to 300 mm. long, smooth or hairy; sepals ovate, scarious (Plate 4); capsule ovoid, slightly exceeding the calyx, circumscissile below the middle, from 2-4 seeded; ripe seeds black, surface dull, striated longitudinally; cross section oval (Plate A., Fig. 4); longitudinal section oval (Plate D., Fig. 4); size, 2¼ mm. x 1 mm.; hilum at center of seed.

An exceptional form found at Evaston, Utah (G. W. Letterman, National Herbarium), is 200 mm. high; has thin leaves; scape 425 mm. long; spike 150 mm. long; petioles nearly as long as the leaves.

Moist and saline soil, from Minnesota to California and the lower St. Lawrence.

Specimens examined: Rimouski County, P. Q. (J. A. Allen, August 5, 1881, National Herbarium); Kearney County, Nebraska (P. A. Rydberg, June 25, 1891, 304 National Herbarium); Nicollett's Northwestern Expedition (C. A. Geyer, July 16, 1839, 276, National Herbarium); Montana (L. F. Ward, 1883, National Herbarium); Han's Fork, Wyoming (L. F. Ward, 1881, National Hebarium); Gottenburgh, Nebraska (Sandberg Collection, June 19, 1889, Herbarium of the University of Minnesota); Oak Wood Lakes, Dakota (Sandberg Collection, June 4, 1892, Herbarium of the University of Minnesota); Brookings, South Dakota (E. N. Wilcox, May 19, 1891, National Herbarium); Western Dakota (Sandberg Collection, Herbarium of the University of Minnesota); Ruby Valley, Nevada (S. Watson, August, 1868, 740, alt. 6,000 ft., National Herbarium); Hayden's Gulch, Granite, Colorado (P. Patagonica, var. nuda, Mrs. S. B. Walker, 1890, 544, National Herbarium); Ft. Bridger, Wyoming (Porter, July, 1893, National Herbarium).

†† Leaves and scape slightly pubescent.

5. P. decipiens Barneoud.—50 mm. to 200 mm. high; leaves linear, channelled, acuminate, erect, three or five veined, margins entire; spike slender,

loosely flowered, 25 mm. to 100 mm. long; scape slightly or densely hairy, 100 mm. to 275 mm. long; calyx obtuse; scarious (Plate 5); capsule ovoid, obtuse, twice as long as calyx, circumscissile at the middle, 2–4 seeded; ripe seeds black, surface dull, minutely granular, cross section oval (Plate A, Fig. 5); longitudinal section oval (Plate D, Fig. 5); size, $1\frac{1}{8}$ mm. x $2\frac{3}{8}$ mm.; hilum not at center of seed.

This species can be distinguished from P. maritima by the shape and surface of the calyx, the shape, length and dehisence of capsule, color of seeds and the position of the hilum.

Salt marshes along the Atlantic coast from Labrador to New Jersey.

Specimens examined: Nahant, Massachusetts (J. A. Manning, July 29, 1886, Herbarium of the University of Minnesota); New Foundland (H. L. Osborn, July 23, 1879, National Herbarium); Newport, Rhode Island (W. W. Bailey, 1878, Herbarium of Purdue University); Cambridge, Massachusetts (Walter Deane, Oct. 5, 1890, National Herbarium); New Haven, Connecticut (A. H. Young, Sept., 1874, Herbarium of Purdue University).

6. P. maritima L.—50 mm. to 225 mm. high; leaves linear, acuminate, channelled, nearly as long as the scape, three or five nerved, margins entire; spike loosely to densely flowered, 25 mm. to 75 mm. long; scape round, slightly hairy, 50 mm. to 325 mm. long; calyx acute, carinate (Plate 6), capsule acute, slightly longer than the calyx, circumscissile below the middle, two seeded; ripe seeds dark brown, surface dull, minutely granular, cross section oval (Plate A, Fig. 6); longitudinal section oval (Plate D, Fig. 6); size, $2\frac{1}{4}$ mm. x $1\frac{1}{8}$ mm.; hilum at center of seed.

Grows in salt marshes along the Atlantic and Pacific coasts, the Gulf of St. Lawrence to Labrador and Greenland.

Specimens examined: San Francisco, California (G. R. Vasey, 1880, 513, National Herbarium); Little Metis, P. Q. (J. A. Allen, July, 2, 1881, National Herbarium); Pigeon Cove, Massachusetts (Aiton Collection, Herbarium of the University of Minnesota); Portland, Oregon (Drake and Dickson, July, 1882, Herbarium of J. M. Coulter); Charlotte, Vermont (Herbarium of J. M. Coulter).

7. P. Tweedyi Gray.—The original description of this species has not been secured. A single specimen, so referred, from Pelican Creek, in the National Herbarium, has been examined. According to its seed characters it belongs in the first section. The other characters of the plant are as follows: 125 mm. high; leaves lanceolate, smooth, five-nerved, margins entire; spike 50 mm. long; scape smooth below, slightly hairy above, cylindrical, 175 mm. long; sepals obtuse, scarious, with a thick centre; capsule oblong, twice as long as calyx, circumscissile below the middle, four-seeded; ripe seeds light brown, surface dull, striated

longitudinally, cross section oval (Plate A, Fig. 7); longitudinal section oval Plate D, Fig. 7); size, $1\frac{1}{2}$ mm. x $\frac{3}{5}$ mm.; hilum at centre of seed.

§ 2. Flowers various; stamens 4; seeds more or less anther shape in cross section.

*Corolla not closed over fruit; leaves lanceolate to linear.

†Leaves lanceolate, acute; scape grooved, angled, slightly hairy; seeds yellow, with smooth surface.

8. P. lanceolata L.—50 mm. to 275 mm. high; leaves lanceolate, acute, tapering gradually into margined petioles, five or seven-nerved, margins entire or slightly denticulate, sparingly to densely hairy; spike densely flowered, capitate at first, in age cylindrical, $12\frac{1}{2}$ mm. to $62\frac{1}{2}$ mm. long; scape grooved, slightly hairy, 225 mm. to 600 mm. long; sepals acuminate, scarious (Plate 7); capsule short, ovoid, circumscissile below the middle, two-seeded, ripe seeds light yellow, having a longitudinal line through the centre lighter than the margins, surface smooth, cross section anther shape (Plate B, Fig. 1); longitudinal section oval (Plate E, Fig. 1); size, 5 mm. x $1\frac{3}{8}$ mm.; hilum at centre of seed.

Dry fields, waste places and along the shores of lakes. (Introduced.)

Specimens examined: Providence, Rhode Island (J. F. Collins, July 15, 1892, National Herbarium); Kootinai County, Idaho (Aiton Collection, September, 1887, Herbarium of the University of Minnesota); North Carolina (G. R. Vasey, 1878, National Herbarium); Virginia (C. Wright, 1853, National Herbarium); Central California (Dr. Palmer, 1876, National Herbarium); Jefferson County, Indiana (C. R. Barnes, May 20, 1876, Herbarium of Purdue University); Pittsford, Vermont (H. L. Osborn, July 2, 1880, Herbarium of Purdue University); Mishawaka, Indiana (E. B. Uline, July, 1891, Herbarium of J. M. Coulter); Arizona (Palmer, 1876, 308, Herbarium of J. M. Coulter); Charlotte, Vermont (June 10, 1879, Herbarium of J. M. Coulter); Hope, Idaho (Sandberg, July, 1887, 113, Herbarium of J. M. Coulter).

†† Leaves linear, acute or obtuse; scape cylindrical, not grooved, densely hairy; seeds dark brown, surface minutely pitted.

9. P. Patagonica Jacq.—75 mm. to 225 mm. high; leaves glabrate or silky lanate, linear, acutely or obtusely pointed, three or five nerved, margins entire; spike 25 mm. to 75 mm. long; densely flowered; scape cylindrical, densely hairy, 100 mm. to 300 mm. long; sepals very obtuse, villous; corolla with broad cordate or ovate lobes (Plate 8); capsule short, ovoid, circumscissile at the middle, slightly longer than the calyx, 2-seeded; ripe seeds dark brown, surface dull, covered with minute pits arranged in longitudinal lines; seeds have a transverse line on the

surface near the center; cross section anther shape (Plate B, Fig. 2); longitudinal section oval (Plate E, Fig. 2); size, 5½ mm. x 2¾ mm.; hilum at center of seed.

Dry ground, from the Mississippi River westward.

Specimens examined: Brazos, Texas (G. C. Nealley, 1889, National Herbarium); San Bernardino County, California (S. B. Parish, April, 1890, Herbarium of J. M. Coulter); Prescott, Arizona (Dr. Palmer, 1869, National Herbarium); San Diego, California (C. R. Orcutt, April 22, 1882, Herbarium of J. M. Coulter); San Quentin Bay, California (Palmer, January, 1889, Herbarium of J. M. Coulter); Austin, Texas (P. Patagonica, var. nuda, Elihu Hall, May 12, 1872, 397, National Herbarium); St. George, Utah (M. E. Jones, April 2, 1880, Herbarium of J. M. Coulter); Portland, Oregon (Drake and Dickson, May, 1889, Herbarium of J. M. Coulter); Uintah, Utah (M. E. Jones, July 2, 1880, alt. 5,000 ft., Herbarium of J. M. Coulter); Los Angeles, California (P. Bigelovii, H. E. Hasse, April, 1888, National Herbarium); Oregon (P. Bigelovii, Mrs. Nevins, National Herbarium.)

Var. gnaphalioides Gray.—75 mm. to 125 mm. high; leaves canescently villous, wool often floccose and deciduous, linear to lanceolate, acutely pointed, margin entire; spike 12½ mm. to 112½ mm. long, densely flowered, varying to capitate and few flowered; bracts oblong to linear, acute, not exceeding the calyx; scape 50 mm. to 225 mm. long, densely woolly; sepals obtuse, villous; capsule slightly longer than the calyx, 2 seeded; size of seeds, 4 mm. x 2 mm.; other seed characters same as species (Plate 9).

Dry, sandy soil, from Minnesota westward and south to Texas.

Specimens examined: Courtland, Minnesota (C. A. Ballard, July, 1892, National Herbarium); Klickitat County, Washington (W. N. Suksdorf, May 16, 1885, National Herbarium); Minnesota (E. P. Sheldon, August, 1891, Herbarium of the University of Minnesota); Oregon (Elihu Hall, 1871, 362, National Herbarium); San Diego, Texas (M. B. Croft, 1884, 112, National Herbarium); Minnesota (Aiton Collection, May 11, 1888, Herbarium of the University of Minnesota); Lincoln, Nebraska (T. A. Williams, June 1, 1890, National Herbarium); Blue Earth County, Minnesota (P. Patagonica, Sandberg Collection, Herbarium of the University of Minnesota); Kearney, Nebraska (J. H. Holmes, August, 1889, National Herbarium); Mexican Boundary Survey (706, National Herbarium); Washington (Dr. Cooper, National Herbarium); Utah Valley, Utah (S. Watson, July, 1869, alt. 4,500 feet, 750, National Herbarium); Eastern Texas (Elihu Hall, April 20, 1872, 396, National Herbarium); Ponca Agency, Oklahoma (Bailey, August 5, 1892, National Herbarium); El Paso, Texas (M. E. Jones, April 16, 1884, Herbarium of J. M. Coulter); Hastings, Nebraska (June

23, 1888, Herbarium of J. M. Coulter); Indian Territory (G. D. Butler, June 2, 1877, Herbarium of J. M. Coulter); Redfield, Dakota (E. Butler, Herbarium of J. M. Coulter).

Var. spinulosa, Gray.—75 mm. to 125 mm. high; leaves linear, very acutely pointed, three or five nerved, nearly as long as the scape, margins entire, white, with long, soft hairs; spike loosely flowered, 25 mm. to 100 mm. long; bracts slightly exceeding the calyx, obtuse, densely hairy; scape covered with soft, white hairs, 100 mm. to 275 mm. long; sepals obtuse, scarious, with a thick centre, densely hairy; slightly longer than calyx, 2 seeded; size of seeds 3¾ mm. x 2 mm.; other seed characters same as species. (Plate 10.)

Found on dry prairies from the Mississippi River westward.

Specimens examined: Blue Earth County, Minnesota (P. Patagonica, John Leiberg, 1883, Herbarium of the University of Minnesota), Zanesville, Minnesota (P. Patagonica, var. gnaphalioides, B. C. Taylor, June, 1891, 177, Herbarium of the University of Minnesota); Crete, Nebraska (P. Patagonica, var. gnaphalioides, Herbarium of the University of Minnesota); St. James, Nebraska (P. Patagonica, var. gnaphalioides, Fred Clements, 1893, 2615, National Herbarium); Jordan, Minnesota (P. Patagonica, var. gnaphalioides, C. A. Ballard, June, 1891, 241, Herbarium of the University of Minnesota); Wilson Creek, Washington (Sandberg Collection, June, 1893, Herbarium of the University of Minnesota); North Dakota (P. Patagonica, G. A. Holzinger, 1891, National Herbarium); New Mexico (P. Patagonica, var. gnaphalioides, Sandberg Collection, April, 1880, Herbarium of the University of Minnesota); Kansas (P. Patagonica, var. gnaphalioides, B. B. Smyth, August 19, 1890, 161, National Herbarium); Kansas (P. Patagonica, var. gnaphalioides, Sandberg Collection, July, 1887, Herbarium of the University of Minnesota); Minneapolis, Minnesota (P. Patagonica, var. gnaphalioides, Sandberg Collection, June, 1892, Herbarium of the University of Minnesota); Pueblo, Colorado (Aiton Collection, June, 1890, 188, Herbarium of the University of Minnesota); Dublin, Texas (C. F. Maxwell, 1893, Herbarium of J. M. Coulter).

Var. aristata, Gray.—100 mm. to 225 mm. high; leaves linear, glabrous to densely hairy, three or five-veined, margins entire; spike cylindrical, loosely or densely flowered, 25 mm. to 125 mm. long; bracts linear, acute, several times longer than the calyx; scape slightly to densely hairy, 125 mm. to 300 mm. long; sepals obtuse, scarious with a thick centre; capsule slightly longer than calyx, 2 seeded; size of seeds, 5 mm. x 2¼ mm., other seed characters same as species. (Plate 11.)

Grows on prairies and in dry soil from the Atlantic coast to California.

Specimens examined: Stone Mountain, Georgia (G. McCarthy, 1888, National Herbarium); San Diego County, California (C. R. Orcut, April, 1870, National Herbarium); Dunson County, Montana (John Lieberg, 1883, Herbarium of the University of Minnesota); Scottville, Texas L. C. Johnson, May 14, 1886, National Herbarium); Ellis, Kansas (Sandberg Collection, June 17, 1888, Herbarium of the University of Minnesota), Providence, Rhode Island (J. F. Collins, July 8, 1892, National Herbarium); Knoxville, Tennessee (Aiton Collection, July, Herbarium of the University of Minnesota); Cranston, Rhode Island (J. F. C., July 7, 1892, National Herbarium); Fayetteville, Arkansas (F. L. Harvey, Herbarium of the University of Minnesota); Colbert's Station, Indian Territory (C. S. Sheldon, June 20, 1891, National Herbarium); Suffolk, Virginia (P. aristata, A. A. Heller, June, 1893, National Herbarium); Indian Territory (Dr. Palmer, 1868, 251, National Herbarium); DeKalb County, Georgia (P. aristata, J. K. Small, July 28, 1893, altitude 1,100 feet, National Herbarium); Converse, Missouri (C. R. B., July, 1877, Herbarium of Purdue University); Vigo County, Indiana (W. S. B., June 10, 1888, Herbarium of DePauw University); Northwest Arkansas (Harvey, 1881, National Herbarium); Nicollett's Northwestern Expedition (P. aristata, C. A. Geyer, June 6, 1839, 275, National Herbarium); New Mexico (E. A. Merus, April 20, 1892, 126, National Herbarium); Eastern Texas (Elihu Hall, April 20, 1872, 399, National Herbarium); Dakota (Sandberg Collection, Herbarium of the University of Minnesota); Texas (P. Patagonica, var. spinulosa, Steele, July, 1881, National Herbarium); Oklahoma (M. A. Carleton, July, 1891, 182, National Herbarium); Wilmington, North Carolina (F. V. Coville, June 28, 1890, 191, National Herbarium), Suffolk, Virginia (A. A. Heller, June 8, 1893, Herbarium of J. M. Coulter); Camp Lowell, Arizona (C. G. Pringle, April 9, 1881, Herbarium of J. M. Coulter); Hockley, Texas (W. F. Thurrow, 1890, Herbarium of J. M. Coulter); Indian Territory (G. D. Butler, June 14, 1877, Herbarium of J. M. Coulter); Converse, Missouri (C. R. B., July 14, 1877, Herbarium of J. M. Coulter).

Var. nuda Gray.—leaves linear, margins entire, scape slender, slightly hairy; sepals obtuse, scarious, with a thick center, hairy; bracts very short, acute.

Specimens examined: California (M. E. Jones, March 27, 1882, National Herbarium).

Var. lanatifolia C. and F.—112½ mm. to 137½ mm. high; leaves linear, acute or obtuse, very densely woolly, five or seven veined, margins entire; spike 25 mm. to 75 mm. long, cylindrical, densely flowered; scape 100 mm. to 225 mm. long, densely hairy; sepals obtuse, scarious, with a thick center, woolly;

capsule ovoid, obtuse, circumscissile at the middle, two seeded; seed characters the same as the species (Plate 12).

Specimens examined: Industry, Texas (W. H. Wurtzelow, 1891, Herbarium of J. M. Coulter).

10. P. minima, *Nov. Sp.*—25 mm. to 50 mm. high; leaves linear, acute, white, with long, soft hairs, margins entire; scape round, very slender, densely hairy, 25 mm. to 125 mm. long; spike capitate, loosely flowered, 6¼ mm. to 18¾ mm. long; sepals obtuse, scarious, with a thick center; capsules ovoid, twice as long as calyx, 2 seeded; seeds light yellow, surface smooth and glossy, cross section anther shaped, longitudinal section oval; size, 2¼ mm. x ¾ mm.; hilum at center of seed (Plate 13).

Separated from P. Patagonica, var. gnapholioides, to which it is closely allied by size of plant, surface of sepals, size of capsule, color, size and surface of seed.

Dry soil in western United States.

Specimens examined: Lincoln, Nevada (P. Patagonica, var. gnaphalioides, Bailey, May 6, 1891, 1912 National Herbarium); Arizona (P. Patagonica, var. gnaphalioides, Dr. Palmer, 1869, National Herbarium); Panamint Valley, California (P. Patagonica, var. gnaphalioides, Coville and Funston, April 17, 1891, 678, alt. 400 meters, National Herbarium); California (P. Patagonica, var. gnaphalioides, C. and F., April 17, 1891, alt. 400 meters, Herbarium of J. M. Coulter).

* Corolla closed over fruit; leaves ovate to lanceolate.

† Scape grooved; capsule oblong, circumscissile below the middle; seeds black.

11. P. hirtella H. B. K.—75 mm. to 500 mm. high; leaves oblong to lanceolate, smooth or slightly hairy, five or seven nerved, margins entire or slightly denticulate; spike cylindrical, very densely flowered, lower ones often scattered, 75 mm. to 300 mm. long; scape round, slightly hairy, 150 mm. to 875 mm. long; sepals obtuse, scarious (Plate 14); capsule oblong, slightly longer than the calyx, circumscissile below the middle, three seeded; ripe seeds black, surface dull, minutely striate longitudinally, cross section slightly anther shape (Plate B, Fig. 3); longitudinal section oval (Plate E, Fig. 3); size, 1⅓ mm. x ⅓ mm.; hilum at center of seed.

Dry ground in western United States.

Specimens examined: Mendocino, California (C. S. Pringle, Aug. 3, 1882, National Herbarium); Los Angeles, California (Dr. H. E. Hasse, June 5, 1888, National Herbarium); Central California (Dr. E. Palmer, 1876, 306, National Herbarium); Sweet Water, California (May 7, 1884, Herbarium of J. M. Coulter); Mendocino, California (C. S. Pringle, Aug. 3, 1882, Herbarium of J. M. Coulter).

†† Scape grooved; capsule ovoid, circumscissile at the middle; seeds yellow.

12. P. Virginica L.—25 mm. to 125 mm. high; leaves ovate to oblong, obtuse, tapering gradually into margined petioles, sparingly to densely hairy, three or five nerved, margins entire or slightly denticulate; spike cylindrical, densely flowered above, often loosely flowered below, 25 mm. to 175 mm. long; scape grooved, densely hairy, 50 mm. to 350 mm. long; sepals obtuse, scarious with a thick center, hairy (Plate 15); capsule short, ovoid, not exceeding the calyx, two-seeded; ripe seeds golden yellow, surface striated longitudinally, cross section anther shape (Plate B, Fig. 4); longitudinal section oval (Plate E, Fig. 4); size 1¼ mm. x ⅞ mm.; hilum at center of seed.

Low, sandy ground from Pennsylvania to Arizona.

Specimens examined: Cincinnati, Ohio (Sandberg collection, June 17, 1883, Herbarium of the University of Minnesota); District of Columbia (W. J. Canby, 1881, National Herbarium); Smithville, Pennsylvania (A. A. Heller, May 30, 1893, 900, National Herbarium); Baumgardner, Pennsylvania (Aiton Collection, May 24, 1890, Herbarium of the University of Minnesota); Tucson, Arizona (Dr. Smart, 1867, National Herbarium); Vinita, Indian Territory (M. A. Carleton, April 17, 1891, 21, National Herbarium); Wichita, Kansas (Sept. 30, 1889, Herbarium of J. M. Coulter); Hockley, Texas (W. F. Thurrow, 1890, Herbarium of J. M. Coulter); Guthrie, Oklahoma (M. A. Carleton, May 28, 1891, 168, National Herbarium), Gillespie County, Texas (G. Jerney, Herbarium of J. M. Coulter); Fayette County, Texas (H. Wurzlow, 1891, Herbarium of J. M. Coulter); Duval County, Florida (A. H. Curtiss, National Herbarium); Lancaster, Pennsylvania (A. A. Heller, June 2, 1893, National Herbarium); Arizona (C. G. Pringle, April, 1881, Herbarium of J. M. Coulter); Hibernia, Florida (W. M. Canby, March, 1869, National Herbarium); Charleston, Indiana (C. R. B., May 14, 1877, Herbarium of Purdue University); Lancaster, Pennsylvania (A. A. Heller, May 30, 1893, Herbarium of J. M. Coulter).

Var. longifolia, Gray.—Leaves oblong, spatulate, 62½ mm. to 125 mm. long, tapering gradually into long petioles, margins slightly denticulate or strongly toothed; seed characters same as species (Plate 16).

Specimens examined: Little Rock, Arkansas (Dr. Hasse, May, 1886, National Herbarium); Brazos, Texas (G. C. Nealley, 1889, National Herbarium); Brazos, Texas (P. Virginica, G. C. Nealley, 1889, National Herbarium); Industry, Texas (H. Wurzlow, 1890, Herbarium of J. M. Coulter).

†††Scape not grooved; capsule oblong, circumscissile below the middle; seeds dark red.

13. P. rubra, *Nov. Sp.*—62½ mm. to 100 mm. high; leaves oblong, densely hairy, sometimes having a reddish color, three or five-nerved, obtuse, margins entire or strongly denticulate, petioles short, densely hairy; spike cylindrical, densely flowered, 12½ mm. to 125 mm. long; scape densely hairy, 25 mm. to 200 mm. long; sepals acute, scarious, with a thick centre (Plate 17); capsule oblong, obtuse, sometimes purple, longer than the calyx, circumscissile below the middle, two-seeded; ripe seeds dark red, surface dull, minutely striate longitudinally, cross section slightly anther shape (Plate B, Fig. 5); longitudinal section oval (Plate E, Fig. 5); size 5 mm. x 2½ mm.; hilum at centre of seed.

Separated from P. Virginica by the dense hairs, acute sepals, shape and dehiscense of capsule, color, cross section and size of seeds.

Sandy soil in western United States.

Specimens examined: Indian Territory (P. Virginica, Dr. Palmer, 1868, 253, National Herbarium); Southwestern Texas (P. Virginica, Dr. Palmer, September, 1879, 1108, National Herbarium); Mesas, Arizona (P. Virginica, var. longifolia, C. F. Pringle, May 3, 1884, National Herbarium); Mexican Boundary Survey (P. Virginica, W. H. Emory, 707, National Herbarium); Mesas, Texas (P. Virginica, var. longifolia, C. F. Pringle, May 3, 1884, Herbarium of J. M. Coulter).

14. P. sparsiflora Michx.—The description of this species, according to Chapman's Manual, is as follows: Leaves smooth, lanceolate, toothed or entire, narrowed into a long petiole; scape much longer than the leaves, pubescent below; spike 6′ to 9′ long, loosely flowered; bracts ovate; calyx lobes obtuse; capsule two-seeded.

Moist pine barrens, Georgia and South Carolina. June—September.

The following specimens so referred were examined: Putnam County, Indiana (D. T. McDougal, July 30, 1888, DePauw Herbarium); Union County, Illinois (G. H. French, July 27, 1878, National Herbarium); Wyandotte, Kansas (Elihu Hall, September, 1869, National Herbarium); Columbia, South Carolina (E. A. Smith, April 15, 1891, Herbarium of the University of Minnesota).

The first three of these should be referred to P. Rugelii and the fourth one to P. Virginica.

§ 3. Flowers polygamo—dioecious; stamens, 2; corolla closed over fruit; seeds irregularly lobed in cross section.

* Leaves linear to filiform, smooth or minutely pubescent; scape very slender.

15. P. elongata Pursh. (P. pusilla, Nutt.).—25 mm. to 100 mm. high; leaves linear to filiform, smooth or minutely pubescent, margins entire; spike 12½ mm.

to 100 mm. long, loosely flowered; scape 31¼ mm. to 150 mm. long, slender, sparingly hairy; sepals obtuse, scarious with a thick center (Plate 18); capsule short, ovoid, obtuse, slightly longer than the calyx, circumscissile at the middle, 4 seeded; ripe seeds light brown, surface dull, deeply pitted, cross section irregularly and deeply lobed (Plate C, Fig. 1); longitudinal section irregularly lobed (Plate F., Fig. 1); size, 1⅝ mm. x ½ mm.; hilum at center of seed.

Dry, sandy soil, or damp places in western and southern United States.

Specimens examined: Shannon County, Missouri (B. F. Bush, April 13, 1889, National Herbarium); Nicollet's Northwestern Expedition (C. A. Geyer, June 20, 1839, 279, National Herbarium); Western Klickitat County, Washington (W. N. Suksdorf, April 26, 1883, National Herbarium); Lincoln, Nebraska (Aiton Collection, May, 1888, Herbarium of the University of Minnesota); Muskogee, Indian Territory (M. A. Carleton, April, 1891, 64, National Herbarium); Iodan Valley, Utah (Sereno Watson, June, 1869, 749, National Herbarium); Portland, Oregon (Drake and Dickson, April, 1887, Herbarium of J. M. Coulter); East Hampton, Long Island (E. S. Miller, June 2, 1877, Herbarium of J. M. Coulter); Oregon (T. Howell, April, 1885, National Herbarium); Georgia (T. C. Porter, 1847, National Herbarium); Dakota (Sandberg Collection, Herbarium of the University of Minnesota); Springfield, Missouri (J. W. Blankinship, 1888, National Herbarium); Montana (R. S. Williams, June 25, 1888, 301, Herbarium of the University of Minnesota); Arkansas (Sandberg Collection, April–May, 103, Herbarium of the University of Minnesota); Seattle, Washington (P. Bigelovii, E. C. Smith, June 21, 1890, National Herbarium); California (P. Bigelovii, M. E. Jones, March 28, 1882, National Herbarium).

16. P. heterophylla Nutt.—25 mm. to 100 mm. high; leaves linear to filiform, smooth or slightly pubescent, margins entire; spike 6¼ mm. to 50 mm. long, loosely flowered, lower ones often scattered; scape smooth or slightly pubescent, very slender, 25 mm. to 125 mm. long; sepals obtuse, scarious with a thick center (Plate 19); capsule conical, nearly twice as long as calyx, circumscissile below the middle, 10–28 seeded; ripe seeds light brown, surface dull, deeply pitted, cross section irregularly and deeply lobed (Plate C, Fig. 2); longitudinal section irregularly lobed (Plate F, Fig. 2); size ⅜ mm. x ¼ mm.; hilum at center of seed.

Low or sandy ground in western and southern United States.

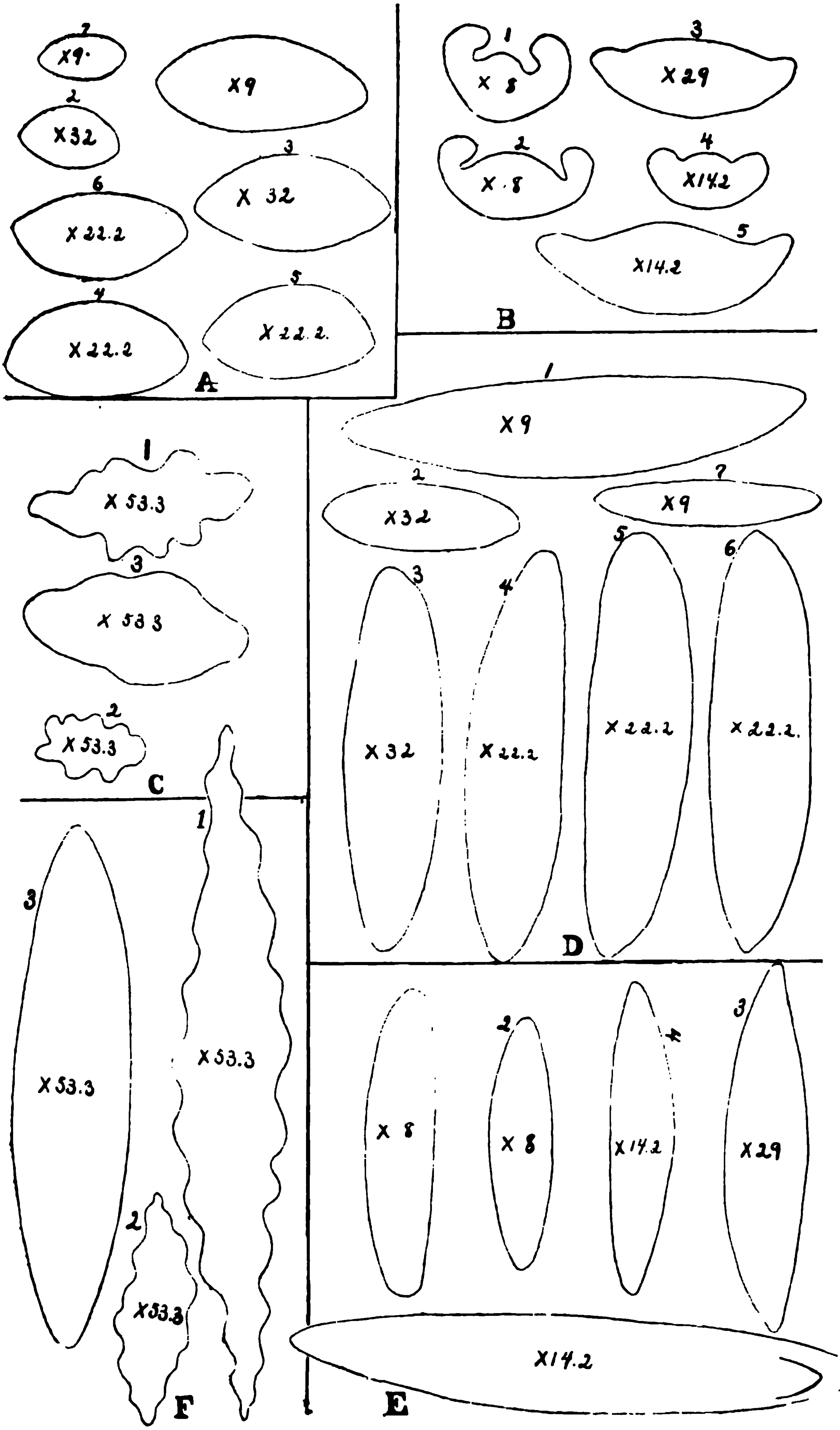
Specimens examined: Statesville, North Carolina (Sandberg Collection, Herbarium of the University of Minnesota); Eastern Texas (Elihu Hall, April 10, 1872, 395, National Herbarium); Wilmington, California (C. G. Pringle, March 31, 1882, National Herbarium); Aiken, South Carolina (W. M. Canby, May, 1869, National Herbarium); Wilmington, California (C. G. Pringle, March

31, 1882, Herbarium of the University of Minnesota); Aiken, South Carolina (W. M. Canby, May, 1869, Herbarium of J. M. Coulter); Florida (Chapman, National Herbarium); Hockley, Texas (W. F. Thurrow, 1890, Herbarium of J. M. Coulter); Wilmington, California (C. G. Pringle, March 31, 1882, Herbarium of J. M. Coulter).

17. P. Bigelovii, Gray.—37½ mm. to 75 mm. high; leaves linear to filiform, obtuse, smooth or minutely pubescent, entire or slightly denticulate; spike 6¼ mm. to 31¼ mm. long, loosely or densely flowered; scape slightly hairy, 50 mm. to 100 mm. long; sepals broadly oval, obtuse, scarious with a thick center; flowers twice as large as those of P. pusilla, stamens exserted but not as long as the style (Plate 20); capsule conical, slightly longer than the calyx, circumscissile below the middle, 5 or 6-seeded; seeds light brown, surface dull, minutely pitted, cross section slightly irregularly lobed (Plate C, Fig. 3); longitudinal section oval (Plate F, Fig. 3); size 1⅓ mm. x ½ mm.; hilum at center of seed.

Moist and saline soil western United States.

Specimens examined: Vacaville, California (W. L. Jepson, May 31, 1891, National Herbarium); Vacaville, California (W. L. Jepson, May 31, 1891, Herbarium of the University of Minnesota); North Lower California (Sandberg Collection, March, 1886, Herbarium of the University of Minnesota).



A
X 9
X 32
X 22.2
X 32
X 22.2
B
X 8
X 29
X 8
X 14.2
X 14.2
C
X 53.3
X 53.3
X 53.3
D
X 9
X 32
X 9
X 32
X 22.2
X 22.2
X 22.2
E
X 8
X 8
X 14.2
X 29
X 14.2
F
X 53.3
X 53.3
X 53.3

A MICROSCOPIC EXAMINATION OF CERTAIN DRINKING WATERS. BY GEORGE J. PIERCE, F. M. ANDREWS, AND A. C. LIFE.

THE EFFECTS OF DROUGHT UPON CERTAIN PLANTS.—AN EXPERIMENTAL STUDY. BY CLARA CUNNINGHAM.

Because of the general knowledge of the subject, and the great influence of drought upon the economics of agriculturists and manufacturers, the following experiments were undertaken.

The purpose of this paper is to show by results of experiments the effects of drought not only upon the general appearance of the plants studied, but more especially upon the different tissues.

The plants used for observation were grown under conditions favorable to normal and healthy growth for three or four weeks or until the plants were large enough to use for experiments; then removed and subjected to drought.

The simple apparatus used to give the favorable conditions in air and soil, consisted, first, of a large glass box 3 ft. long, 2 ft. wide, and 1½ ft. deep, and fitted with a glass cover; second, a number of Erlenmeyer flasks fitted with perforated stoppers holding long glass tubes. These flasks were filled with water and inverted so that the glass tubes dipped into shallow pans containing the plants in flower pots.

The plants used in the experiments were Oxalis, Canna, corn, common bean, Castor bean and cucumber. In making the drawings the camera lucida was used.

Two Oxalis plants were taken from the green house. These plants were of equal size and uniform appearance. One of these plants was examined immediately, and one was placed in the dry air of the laboratory and a minimum amount of moisture supplied to the roots.

Comparing the two plants as regards general appearance, I noticed that the oldest leaves of the plant subjected to drought soon grew yellow and dropped off. The leaves just budding when brought into drought grew very slowly, and did not expand properly, and presented a peculiarly twisted or folded surface. After being subjected to drought five weeks the leaf stalks had grown in length only three inches, were of an intense dark green color, and somewhat stiffened or woody. Leaves of plants subjected to drought also showed a tendency to earlier acquire the xanthophyll than those of plants under normal conditions. The effect

of drought on the trichomes caused the plant to become exceedingly viscous, giving the plant a glistening appearance. Another effect of drought on the general appearance of the plant was the prevention of the opening of the flower buds, which soon withered.

In the case of the plant kept under normal conditions for the same length of time the leaves expanded perfectly, the leaf stalks were much elongated and quite flexible. The plant was of lighter green color, and in general did not show the dwarfed appearance of plants subjected to drought.

When examined with a microscope the different tissues are found to show as marked differences as the general appearance of the plants.

When we compare two strips of epidermis, one taken from the lower surface of the leaf of the plant grown under normal conditions and one from a plant subjected to drought; the first difference noticed is that of the turgescence of the plant cells.

The cells of the plants grown under normal conditions are very large and turgescent.

The cells of plants subjected to drought lack turgescence, and show a weak, flaccid cell wall, are also much smaller than these under influence of moisture. The growth of the cells being retarded, the stomata are brought nearer to each other so that the number per inch is 1400, while the number under normal conditions is only 400 per inch.

Drought also causes a slight change in the guard cells, producing a corresponding change in the breadth of the stomata.

See figures I and II.

The trichomes of Oxalis are numerous and are of the glandular variety. Their distribution over the surface of the leaf corresponds to that of the stomata. On the epidermis of plants subjected to drought the trichomes are more numerous than those of plants grown under moist conditions; are also shorter and more globular.

The cells of normal plants contain an abundance of starch; under the influence of drought this starch is greatly diminished.

The Canna was the next plant observed, and was if possible more changed by drought as regards manner of growth than the Oxalis. The plant was only subjected to drought for three weeks, but in that short time the growth was considerably retarded.

When the seeds of the Canna are allowed to germinate under conditions of drought, the plantlets grow very slowly, sending out numerous opposite leaves. When the plants were removed to good conditions for growth, they refused for

several weeks to grow; then above the stunted portion strong leaf stalks shot upward, and in three weeks had attained a height twice as great as the stunted portion had reached in two months. The leaves of plants grown under normal conditions were alternate.

The effect of drought on the Canna was not as immediate as in case of the Oxalis, not causing wilting, but in time became more decided because of the changed position of the leaves.

The structural differences were quite apparent. In a strip of epidermis taken from the leaf of a normal plant the cells were irregular and angular; the angles were held firmly in position by the turgescence. The guard cells showed a firm outline. The stomal openings were quite narrow. The stomata were slightly more numerous under drought, being 600 per inch, in normal plants 400 per inch. The stomata openings were also wider in drought. See figures 3 and 4.

The common bean will apparently withstand more drought than any of the plants examined. The general appearance of the plant was not materially changed. The growth, however, was retarded by drought, the stalk only growing half as long as the stalk of normal plant in the same length of time. The shorter stalk was also larger in diameter. The plant grown under favorable conditions was more flexible, not because of lack of turgescence, but because of lack of thicker cell walls developed by drought.

The plant cells were smaller and less turgescent when subjected to drought. The stomata were increased in number, the guard cells metamorphosed, and the stomal openings larger than those of plants grown in moisture.

The trichomes of the bean are not branched, and are of the non-glandular variety. When subjected to drought they remain shorter, and the diameter is increased slightly.

In a cross section of the stem of plants subjected to drought, the non-turgescence of the cells was shown, also a slight thickening of the cell walls. This thickening was demonstrated by the time required for the iodine to penetrate the cell walls as compared with the walls of cells grown in favorable conditions. See figures 5 and 6.

The general appearance of corn showed the effects of drought more in change of color and the tendency of the leaves to twist and wrinkle lengthwise. The growth was also stunted.

The epidermis was more difficult to separate from the underlying tissue of plants subjected to drought than from plants under normal conditions. The characteristic difference in turgescence of the cells was shown, also metamorphosed guard cells and stomata. See drawings, plates 7 and 8.

The Castor bean can withstand the least amount of drought of any of the plants observed. After being subjected to drought for one week, there was a decided change in general appearance. The leaves wilted and shrivelled, and the stalk was not turgescent enough to remain erect, but wilted. It was almost impossible to obtain the epidermis from the leaf because of its clinging to the underlying tissue. By referring to the accompanying drawings of the Castor bean (Plate 9) the differences in structure of the plants grown under the different conditions may be seen. The stomatal guard cells and the surrounding tissue cells are seen to be smaller in plants subjected to drought. The stomata are increased in number from 500 per inch in moist air to 700 per inch in drought.

A cross section of the stem showed the characteristic difference in turgidity and size of the cells.

The effect of drought on the cucumber in general is to destroy the turgescence and give the stem a wilted appearance. The number of stomata are increased in drought, as seen in figure 10.

From the above experiments it may be seen that immature plants subjected to drought for only a short time have decided changes in general appearance and structure. It seems very probable that in different plants such changes might occur, as a result of drought, as would greatly change not only the habits of the plant but its life history.

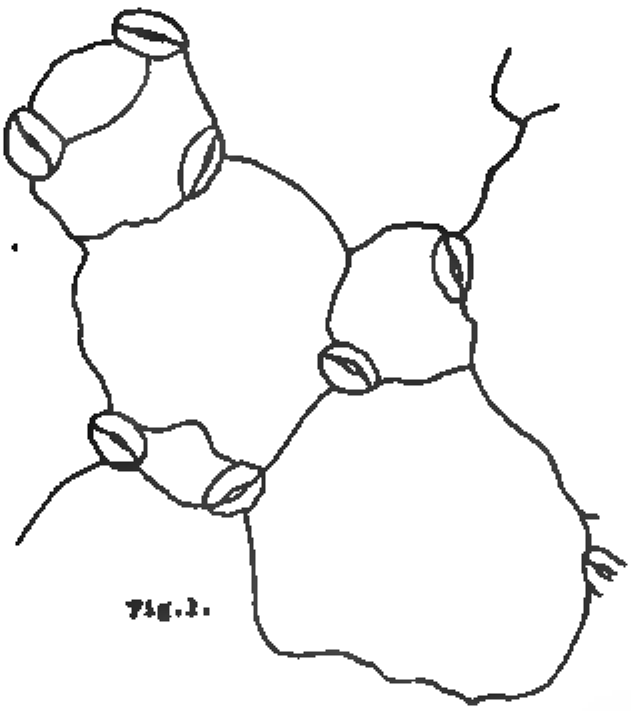


Fig.1.

Epidermis, leaf of Oxalis grown under normal conditions.

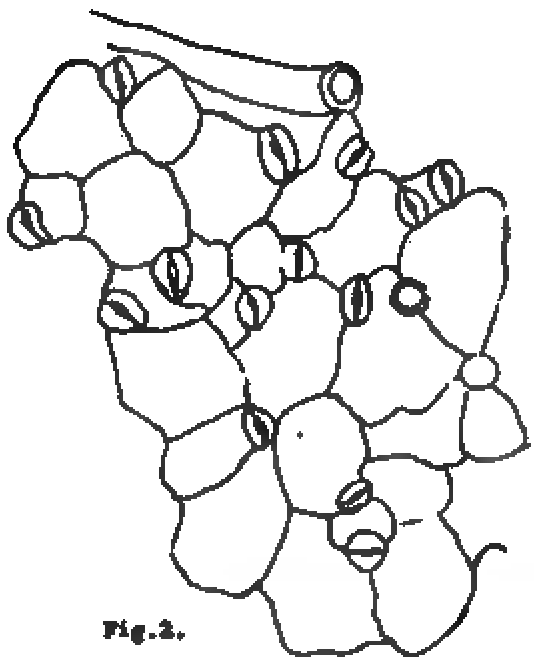


Fig.2.

Epidermis from Oxalis subjected to drought.

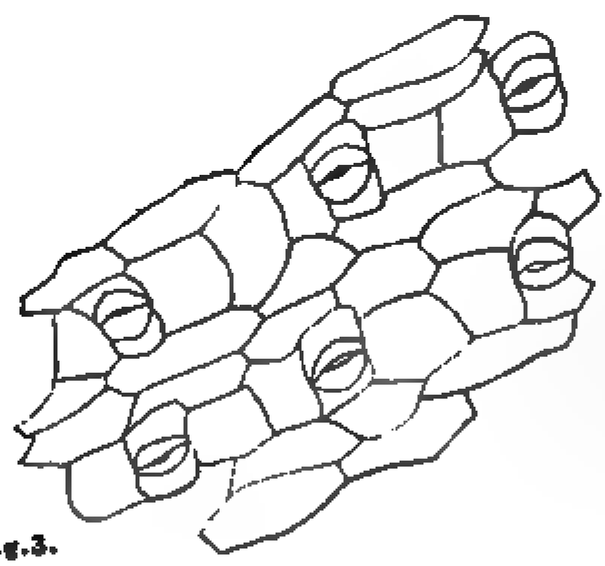


Fig.3.

Epidermis, leaf of Canna, grown under normal conditions.

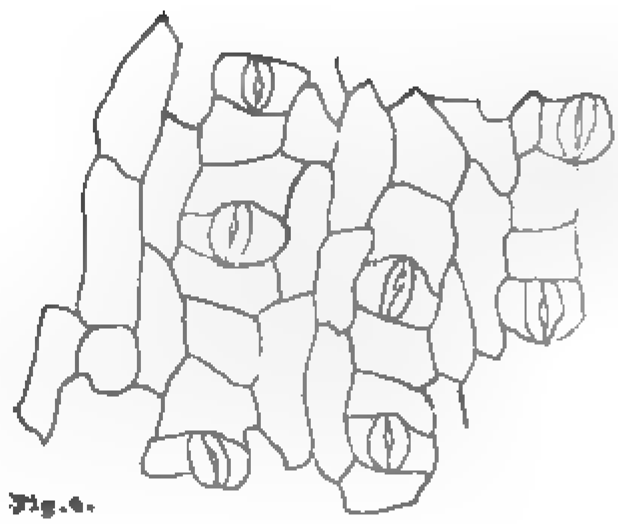


Fig.4.

Epidermis, leaf of Canna, subjected to drought.

Fig.5.

Epidermis leaf of common bean, grown under normal conditions.

Fig.6.

Epidermis, leaf of common bean, plant subjected to drought.

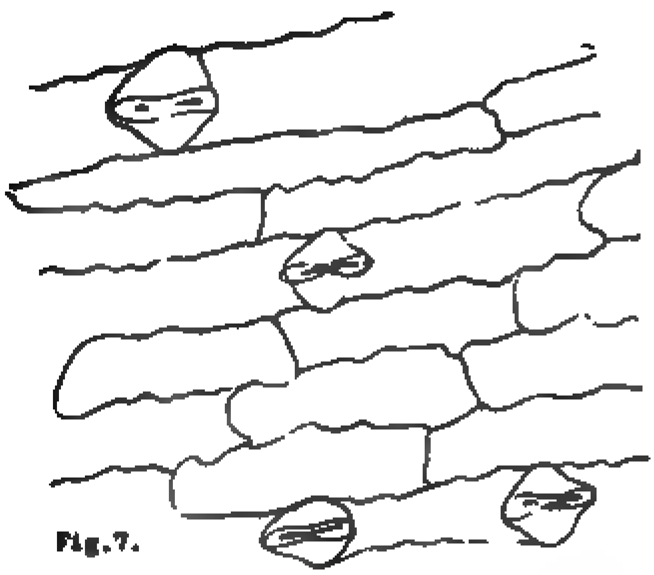


Fig.7.

Epidermis,Corn grown under normal conditions showing turgescent cells.

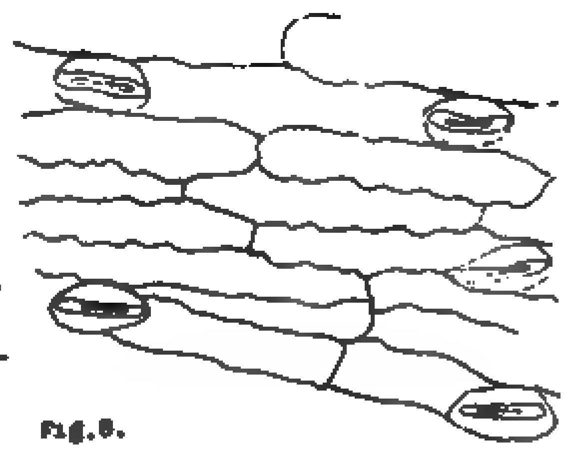


Fig.8.

Epidermis,blade of corn, subjected to drought

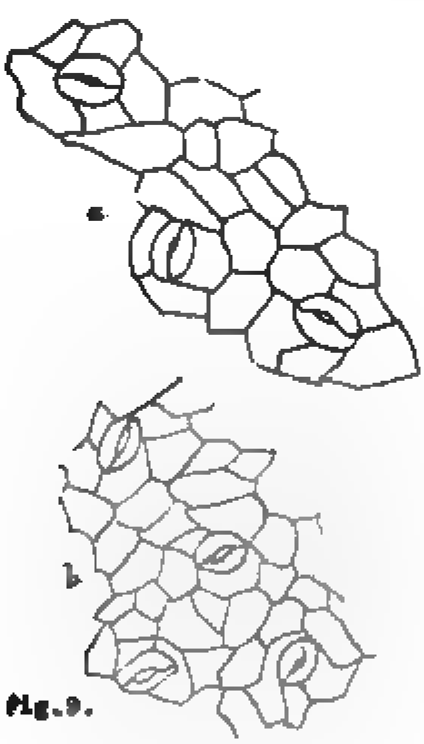


Fig.9.

Epidermis Castor bean.
a-Under normal conditions.
b-Subjected to drought.

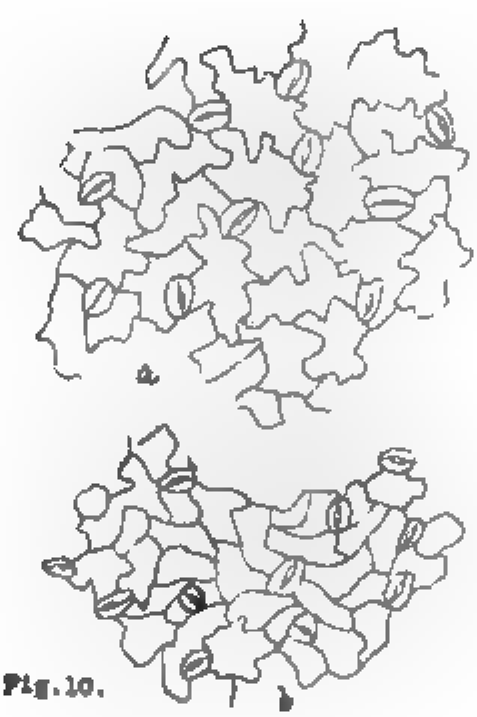


Fig.10.

Epidermis of Cucumber.
a-Under normal conditions.
b-Subjected to drought.

Additions to the Cryptogamic Flora of Indiana. By J. C. Arthur.

It was not my privilege to be present at the meeting of the Academy a year ago, at which time I was appointed to take charge of a part of the work of the Biological Survey of the State. No official notice of my appointment has ever reached me, and no material appertaining to the Survey, such as herbarium specimens upon which the work of the Survey is based, reserve or duplicate specimens for exchange, books, circulars, extra copies of lists already reported, etc., have yet been turned over to me, if, indeed, such exist. This state of affairs has caused some doubt in the mind of the writer as to the exact degree of responsibility which has fallen to him, and some uncertainty as to the scope of the work he is expected to superintend.

Some good intentions of the earlier part of the year, to send out appeals to the botanists of the State for their support and active coöperation, were allowed to remain in embyro. A year has thus passed, and no special effort has been made to further the interests of the Survey. But the writer desires to state most emphatically, and he would do it orally were he able to be present at the current meeting of the Academy, that this lack of activity is not due to a want of sympathy with the aims of the Survey or unwillingness to give as much effort to the work as time and opportunity permit.

The following list of species is the result of setting aside such specimens as came to my attention during the year, that have not appeared in the previous lists of the Survey. They have been handed to me by various persons, but all residents of Lafayette, in part members of the University and in part citizens of the town. It includes all classes of cellular cryptogams coming to hand except *Uredineæ*, which are reported in a paper to be presented by Miss Lillian Snyder.

It is to be hoped that at the next annual meeting a far larger showing can be made, although the present list is by no means uninteresting. If every collector will send to the writer whatever may come in his way, whether its value is known or not, it will be easy to greatly extend the list, and in this way to distribute the labors of the Survey so that it will not be burdensome, and, indeed, may yield a measure of scientific profit to the participants.

ALGÆ.

Cladophora glomerata genuina Kirch.

On wood in Wabash River. Tippecanoe 10, 1896 (R. I. Hight.)

Chamæsiphon confervicola A. Br.

On Hydrodictyon, Spirogyra and other algæ. Tippecanoe 11, 1896 (Miss K. E. Golden).

AGARICINEÆ.

Lepiota procera Scop.

On ground in open woodland. Tippecanoe 5, 1896 (Throckmorton).

This well known edible agaric was found in considerable abundance in one place. The specimens were finely developed, the pileus of many measuring four to five inches in diameter. They were distributed to several families, and probably as many as a score of persons ate of them. They were palatable and pronounced good eating. The results, however, were unpleasant, for a majority of the persons who ate of them, even in small amount, were made sick. The symptoms in this instance were not those of poison, but everything indicated that the mushrooms were highly indigestible. Whether this was due to the mode of cooking, or to the age of the specimens, or to some other cause, was not ascertained.

Pleurotus sapidus Kalch.

On decaying stump. Tippecanoe 7, 1895 (Arthur).

This is also a large edible species, but its merits were not tested. It made its appearance about the first of July in a lawn where a tree had been cut down and the trunk cut off about six inches below the surface of the ground. The fungus flourished until a yellow mycetozoan (*Tilmadoche gyrosa*) spread over the gills, and in the course of a week devoured the whole fungus, leaving only a small amount of debris not exceeding the size of a walnut. The mycetozoan, having no more food, spread out over the grass of the lawn a yard in all directions and went into the fruiting stage. After a few days a fresh crop of the agaric appeared, the rain dissolved the fruit-heads of the mycetozoan, and it again attacked the fungus. This alternation continued until frosts and chilly days put an end to the activity of the mycetozoan. The agaric continued to flourish, however, throughout the winter, making some growth whenever not frozen, and proving, in fact, of about the same hardiness and vigor as winter wheat plants. When frozen solid, a piece taken into a warm room appeared as fresh and unharmed upon being thawed as if never frozen. The severe changes of thawing and freezing in March and April at last killed the fungus.

LICHENES.

Cladonia mitrula Tuck.

On ground in pastures. LaPorte 6, 1883 (Arthur). Determined by Fink.

MUCORACEÆ.

Mucor racemosus Fres.

On starchy food (cracker). Tippecanoe 2, 1893 (Miss Lillian Snyder).

Rhizopus nigricans Ehrenb.

On germinating seeds. Tippecanoe 2, 1896 (Arthur).

Rhizopus elegans (Eidam) Ber. & De T.

On masses of corn smut. Tippecanoe 2, 1896 (Wm. Stuart).

Thamnidium elegans Lk.

On vegetable refuse in greenhouse. Tippecanoe 1, 1896 (Arthur).

MISCELLANEOUS FUNGI.

Ascophanus carneus (Pers.) Boud.

On paper lying against sheep's dung. Tippecanoe 3, 1896 (Arthur).

Chætomium bostrychodes Zopf.

On sheep's dung. Tippecanoe 3, 1896 (Arthur). Determined by J. B. Ellis.

Monilia Martinii E. & S.

On a culture of mold in the laboratory. Tippecanoe 3, 1896 (Arthur).

Determined by J. B. Ellis, who thinks that while not agreeing exactly with this species as it usually appears, yet is not distinct enough to merit a separate description.

Podospora penicillata E. & E.

On sheep's dung. Tippecanoe 2, 1896 (Arthur).

Stilbum erythrocephalum Ditm.

On rabbit's dung. Tippecanoe 10, 1896 (Burrage).

Æthalia bombacina Pers. (*Institale bombacina* Fr., *Sporotrichum bombacinum* Lk.)

On dead wood under a board walk. Tippecanoe, 1895 (Stanley Coulter).

Determined by J. B. Ellis, who has also received it from North Carolina, Louisiana and Mexico, collected in similar situations. It forms large, thick, cake-like masses, six inches or more in length, of a dark purple color, with an efflorescence of white spores, and exudes a watery liquid that collects both inside and outside the mass in copious amber-colored drops.

THE UREDINEÆ OF TIPPECANOE COUNTY, IND. BY LILLIAN SNYDER.

Up to the present time about seventy species of *Uredineæ* have been found within Tippecanoe County, out of which there are about fifteen that are new to the State of Indiana. These species I wish to present to you, noting the points of interest concerning them. All the species herein mentioned have been closely examined by the writer in order to detect any differences from typical specimens that might exist, caused from difference in locality or otherwise.

Some of the additional species mentioned are so rare that it was with difficulty a good specimen was collected, while others are so abundant that it seems strange they have not been previously reported.

The collector's name, with date of collection, follows the name of the host, and the specimens may be found in the herbarium of the persons named. Those not so designated are in my own collection.

Sincere thanks are extended to Dr. J. C. Arthur for his assistance in the determination of many of the host plants.

Æcidium asterum Schw. Very common.

On *Aster* sp., 6, 1896.

Æcidium compositarum. As this is only a convenient name under which to place forms found on compositæ, the host holds an important part in the classification. The form on *Eupatorium* was found in May and June, growing in marshy ground. All plants observed were well covered with the *Æcidia.*

On *Eupatorium perfoliatum*, 5, 6, 1896.

Æcidium euphorbiæ Gmel. Common.

On *Euphorbia maculata*, 8, 1887 (Arthur).

On *Euphorbia dentata*, 5, 1896.

Æcidium geranii DC. Rare.

On *Geranium maculatum*, 5, 1894 (Golden).

Æcidium impatientis Schw. Common.

On *Impatiens pallida*, 6, 1896.

Æcidium œnotheræ Pk. Common.

On *Œnothera biennis*, 6, 1896.

Æcidium pentastemonis Schw. was collected in the immediate vicinity of Lafayette by Mr. Stuart, and although the species was found in abundance in that particular locality, a close examination of the *Pentstemon* plants on the part of others failed to reveal the parasite in other parts of the county.

The spots are irregularly scattered over the leaf, appearing purple in the fresh specimen, turning brown when dry.

On *Pentstemon pubescens*, 5, 1896 (Stuart).

Æcidium Ptelea B. & C. Rare.

On *Ptelea perfoliatum*, 6, 1896.

Æcidium ranunculacearum DC.

Cultures have been made by Plowright working out the life history of the species and thus connecting the first and third stages, but it is probable that the American differs from the European forms.

On *Anemone Pennsylvanica*, 6, 1895.

Æcidium trillii Burrill. In this species the sori are usually in circular patches, the central portion free from the rust, or eating through to the upper side of the leaf.

The species is very closely allied to *Æcidium courallancia* of Schweinitz.

On *Trillium sp.*, 6, 1894 (Golden).

Æcidium verbenæ Spreng. is extremely abundant. In the last season almost every plant of *Verbena stricta*, I observed, was affected with the rust. The plants grow along the roadside, and even on streets leading out of town.

The fungus may be found on the lower leaves of the host near the ground, and the *Æcidia* occur usually in white circular spots, scattered irregularly over the under surface of the leaves and producing a discoloration of the leaf.

On *Verbena stricta*, 6, 1896.

Ceroma agrimoniæ Schw. Common.

On *Agrimonia Eupatoria*, 7, 1896.

Coleosporium hydrangeæ (B. & C.) Only the uredospores of this species were found, and these seemed to be in great abundance in various parts of the county.

The species is described by most writers under the genus *Uredo*, but the third stage has recently been found and connected with the *Uredo*, thus putting it in the proper genus.

On *Hydrangea arborescens*, 9, 1896.

Coleosporium ipomoeæ (Schw.) Burrill. In this the teleutospores do not usually appear until late in autumn after frost. They occur in bright orange sori with spores from four to six celled, cells soon separating at the septa and losing their bright color.

On *Ipomæa* sp. 12, 1895 (Arthur), 7, 1896.

Coleosporium Sonchi-arvensis (Pers.) Lev. Common.

On *Solidago* sp. 6, 1896.

Diorchidium lateripes (B. & R.) Mg. Common.

On *Ruellia strepens*, 11, 1895 (Stuart), 6, 1896.

Gymnosporangium macropus Lk. Common.

On *Juniperus virginiana*, 3, 1889 (Bolley).

On *Pyrus coronaria*, 9, 1892 (Arthur), 6, 1896.

Melampsora populina (Jacq.) Lev. Common.

On *Populus monilifera*, 7, 1896.

Melampsora Salicis-capreæ (Per.) Wint. Common.

On *Salix discolor*, 8, 1896.

Phragmidium fragariæ (DC.) Wint. Rare.

On *Potentilla canadensis*, 6, 1896.

Phragmidium speciosum (Fr.) Arth.

Stages I and II of this species are found on the same host, the *æcidia* appearing in summer as reddish-yellow spots that follow the veins and petioles of the leaves, producing much distortion. The third stage appears about two months later, and, in specimen examined, on the same individual host as the *æcidia*.

On *Rosa Carolina*, 7, 9, 1895 (Arthur), 5, 1895.

Puccinia Anemone-virginianæ Schw. was first described by Schweinitz as early as 1822, in the "Synopsis Carolina," under the name *P. anemone-virginianæ*, and is referred to by him in a later work under the name *P. solida*.

The sori occur in dark-brown hardened spots, difficult to free from the host. The spores are long and linear, and slightly colored.

Only the third stage is known, and is quite common, first appearing about the month of July.

On *Anemone cylindrica*, 7, 1892 (Arthur).

Puccinia andropogi Schw. Very common.

On *Andropogon scoparus*, 9, 1896.

On *Andropogon furcatus*, 9, 1896.

Puccinia augustata Pk. Common.

On *Scirpus atrovirens*, 9, 1896.

Puccinia asteris Duby. Common.

On *Aster diffusus*, 6, 1896.

Puccinia Bolleyana Sacc. Rare.

On *Carex sp.*, 11, 1888 (Bolley).

Puccinia convolvuli (Per.) Cast. Common.

On *Convolvulus sepium*, 10, 1895 (Stuart).

On *Polygonum dumetorum*, 6, 12, 1896.

Puccinia cyperi Arth. Common.

On *Cyperus strigosus*, 9, 1896.

Puccinia circaeæ Pers. Rare.

On *Circæa lutetiana*, 7, 1896.

Puccinia coronata Cda. Common.

On *Avena sativa*, 11, 1896 (Stuart).

Puccinia caricis (Schum.) Wint. Very common.

On *Carex sp.*, 10, 1896.

Puccinia eleocharidis Arth. Rare.

On *Eleocharis palustris*, 11, 1896.

Puccinia flosculosorum (A. & S.) Wint. Common.

On *Taraxacum officinale*, 5, 1895; 6, 1896.

Puccinia graminis Per. Common.

On *Avena sativa*, 10, 1896.

On *Dactylis glomerata*, 10, 1896.

On *Hordeum jubatum*, 11, 1896.

Puccinia interstitialis (Schl.) Franz. Common.

On *Rubus villosus*, 5, 1896.

Puccinia Kuhniæ Schw. Rare.

On *Kuhnia eupatoriodes*, 9, 1888 (Bolley).

Puccinia Lobeliæ Gerard. Rare.

On *Lobelia syphilitica*, 8, 1896.

Puccinia ludibunda E. & E.

The original description of this species may be found in the proceedings of the Philadelphia Academy of Science, 1894. The projections at the apex of the spores, spoken of there, resembling closely *Pucc. coronata*, I have observed in some cases, but they are very small and inconspicuous.

The host plant was found in low ground along the Wabash River. Most all plants observed bore some rust, but, generally, the sori were few and scattering, and being small were difficult to see.

On *Carex sparganioides*, 10, 1896.

Puccinia menthæ Pers. Common.

On *Monarda fistulosa*, 6, 1896.

On *Blephilia hirsuta*, 7, 1896.

On *Pycnanthemum sp.*, 10, 1896.

Puccinia nigrovelata Ell & Tracy. Rare.

On *Cyperus strigosus*, 3, 1896.

Puccinia nolitangere Cda. Found in the extreme northern part of the county in low ground. The plants in the immediate vicinity were badly affected with the rust, but efforts to find the species in other parts of the county proved unsuccessful.

The species was first described by Corda in Icones IV as early as 1841.

On *Impatiens fulva*, 9, 1896.

Puccinia Physostegiæ P. & C. Only the teleutospores were examined. These are usually placed obliquely on the pedicels, but none were found with pedicels parallel to the septum, as they are in the typical *Diorchidium* genus.

The original description of this species occurred in 1878 in the 29th Rep. N. Y. St. Mus.

On *Physostegia virginica*, 8, 1895 (Arthur).

Puccinia panici. Very common.

On *Panicum capillare*, 9, 1896.

Puccinia prenanthis (Per.) Fhll. Very rare.

On *Prenanthes alba*, 5, 1895 (Golden).

Puccinia podophylli Schw. Common.

On *Podophyllum peltatum*, 6, 1896.

Puccinia polygoni-amphibii Pers. Common.

On *Polygonum erectum*, 6, 1896.

Puccinia Rubigo-vera (DC.) Wint. Common.

On *Glumes of Rye*, 7, 1889 (Arthur).

On *Elymus virginicus*, 7, 1896.

Puccinia Sporoboli Arth. Found on *Sporobolus cryptandrus*, differs some from the form found on *S. heterolepsis*. On the former the spores are larger, usually constricted at septa, pedicels much longer, generally two or three times the length of the spore, and slightly tinted. The one-celled teleutospores spoken of in the original description were not present in specimen examined, probably due either to the different host species or more mature state of material. The grass is found in sandy places in great abundance. The leaves and stems are usually entirely covered with the rust, causing the leaves to curl.

On *Sporobolus cryptandrus*, 4, 1896.

Puccinia triodiae Ell. and Barth. Has been until recently classed under *Pucc. emaculata* Schw., and has probably been reported as that species, but there are some differences existing along with the different hosts, making it certainly justifiable in separating the forms.

The host plant is found in dry, sandy soil, and the rust is very abundant, the sori usually covering the whole upper surface of the leaves. All plants observed were badly infected with the fungus. There are some differences in the teleutospores growing upon the different species of *Triodia*, mainly in size and shape of spores.

On *Triodia seslerioides*, 3, 1896.

Puccinia tenuis Burrill. Rare.

On *Eupatorium ageratoides*, 5, 1896.

Puccinia tanaceti DC. Common.

On *Helianthus grosse-serratus*, 6, 1896.

Puccinia vulpinoides D. & H. Rare.

On *Carex vulpinoides*, 11, 1888 (Bolley).

Puccinia windsoriae Schw. Very common.

On *Muhlenbergia sylvatica*, 9, 1896.

Puccinia xanthii Schw. Very common.

On *Xanthium Canadense*, 6, 1896.

On *Ambrosia trifida*, 6, 1896.

Rœstelia lacerata (Sow.) Fr. Common.

On *Crataegus sp.*, 6, 1896.

Uromyces appendiculata (Pers.) Lév. Common.

On *Phaseolus diversifolius*, 6, 1896.

Uromyces caladii (Schw.) Farl. Common.

On *Arisæmia triphyllum*, 5, 1896.

On *Arisæmia Dracontium*, 6, 1896.

Uromyces Euphorbiæ (Schw.) C. & P. Common.

On *Euphorbia dentata*, 7, 1896.

On *Euphorbia hypericifolia*, 6, 1896.

*Uromyces gaurina** (Pk.)

The second stage or *uredo* stage of this species has been described by Peck in the Botanical Gaz. IV as early as 1879 under the name *Trichobasis gaurina*, of which he says that it is probable that the species is the second stage to some species of *Uromyces* or *Puccinia* not yet known. I found the teleutospores July 25, 1896, on the same host with *uredo* which correspond with those described by Peck. So I take it that the form recently found belongs to what has been previously known as *Uredo gaurina*, but must now be classed under the genus *Uromyces*.

On *Gaura biennis*, 7, 1896.

Uromyces Howei Pk. Common.

On *Asclepias incarnata*, 10, 1896.

On *Asclepias cornuti*, 9, 1896.

Uromyces hedysari-paniculati (Schw.) Farl. Common.

On *Desmodium Canadense*, 6, 1896.

On *Desmodium diellenii*, 6, 1896.

Uromyces junci (Schw.) Tul. Common.

On *Juncus tenuis*, 10, 1896.

Uromyces lespedezæ (Schw.) Pk. Rare.

On *Lespedeza repens*, 9, 1894.

Uromyces orobi (Per.) Wint. is rare. In only one locality could I find plants affected with the fungus, and then only a very few leaves could be found bearing rust. Plants not ten feet distant seemed to be perfectly free from any infection.

On *Vicia Americana*, 10, 1896.

**Uredo sori* scattered, brown; spores globose, finely echinulate 19-22μ w. by 20-26μ l.; teleutosori dark brown, erumpent, roundish; spores sub-globose, ovate or oblong, vertex strongly thickened with a blunt-colored apiculus, smooth, 19-24μ w. by 20-30μ l.; pedicels once to three times the length of the spore, hyaline.

Uromyces polygoni (Per.) Fkl. Common.

On *Polygonum aviculare*, 6, 1896.

Uromyces trifolii (A. & S.) Wint. Rather common.

On *Trifolium protense*, 7, 1896.

Uromyces terebinthi (DC.) Wint. Very common.

On *Rhus toxicodendron*, 10, 1896.

Besides these species a few additional host plants have been found, the most interesting and noteworthy of which is *Polygonum dumetorum* var. *scandens*.

A number of species are common on *Polygonum* species, but in the past season *Pucc. Convolvuli* has been found upon this host in great abundance. The rust occurs on the leaves, petioles, and occasionally on the stems in about the same manner as it does on plants of *Convolvulus*. In fact, had I not been especially fortunate in securing the host plant in bloom I should certainly have been led to believe that I had found the rust upon some species of *Convolvulus*, as the foliage and manner of growth of the two plants are very similar.

Although there are some differences existing between the two forms of fungi, I believe without a doubt they belong to the same species.

Uredospores growing upon *Polygonum dumetorum* are not so uniform, and of a much darker color than those on *Convolvulus*, while *teleutospores* upon the former are slightly larger, more varied, with pedicles more deeply tinted, and sometimes placed obliquely on the spore.

The uredospores were collected the latter part of June, and were not abundant. The marked differences between these spores and uredo of authentic specimens of *Uromyces polygoni* and *Puccinia Polygoni amphibii* led me to make further search for material, and in the early part of the present month the teleutospores of the above species were found in great abundance upon the same individual host as the earlier stage. Host plants of the same species in various other localities of the county were examined, but were not affected in the least with any rust.

Dactylis glomerata (*Pucc. graminis*). As far as I have been able to make out, *Pucc. graminis* has never been reported as growing upon this host, the usual species found upon it being *Pucc. coronata* Cda. Through the experiments of Eriksson, he has found that, among other host plants, *Pucc. graminis* will grow upon *Dactylis glomerata*.

The rust was found in the Experiment Station yard, appearing in linear sori, and almost covering both sides of the leaves of the host. Although the grass grew there in great abundance, only one or two tufts seemed to be infected with the fungus.

Hordeum jubatum (*Pucc. graminis*). Although some search has been made for this plant, I have never found it in great abundance. Gray's Manual gives the range sandy sea shore, Upper Great Lakes and westward. Bulletin of Indiana Experimental Station, No. 29, reports the plant as frequently occurring along the Wabash River, but rather sparingly.

The few plants that I have found have their leaves dotted over rather scantily with the uredo, and the culms entirely covered with the teleutospores of *P. graminis*, the latter appearing sub-epidermal.

TRAUMATROPIC CURVATURE OF TENDRILS. BY D. T. MCDOUGAL.

MECHANISM OF CURVATURES OF ROOTS. BY D. T. MCDOUGAL.

ON THE OCCURRENCE OF THE RUSSIAN THISTLE (SALSOLA KALI TRAGUS) IN WABASH COUNTY. BY ALBERT B. ULREY.

[ABSTRACT.]

The Russian thistle is recorded as occurring in two localities near North Manchester, Ind. One locality is on the Erie R. R., while the other is somewhat more than a half mile from the Big Four road.

SOME ADDITIONS TO OUR KNOWLEDGE OF THE ANATOMY AND EMBRYOLOGY OF THE HOLOSTOMIDÆ. BY L. J. RETTGER.

[ABSTRACT.]

The holostomidæ belong to the class of trematodes and to that division of this class designated as the *digenea*, on account of their passing through two stages, entirely marked off from each other in reaching maturity. They vary in size from almost microscopic forms to forms five to ten mm. long. The holostomidæ are usually parasitic in the intestines of birds, though they have been noted occurring elsewhere. Comparatively few forms are known through all their larval stages, and in some of the few cases apparently known there is still a large element of uncertainty. This lack of definition is caused by the difficulty of finding the larval forms, and then growing the larvæ into the adult parasites.

During last winter while engaged in studying some forms of distomum, I chanced to find living parasites in the liver of Lymnæa stagnalis innumerable

larvæ, which, upon careful study, seemed to be larval forms of some trematode. These larvæ had been observed before and designated as tetracotyle from their four sucker-like depressions. The complete literature on the form in question showed that its anatomy was practically entirely undetermined, and study revealed that the few statements made by the earlier observers were not correct. The form was therefore subjected to a critical morphological study and its anatomy fairly well determined. The observations were, however, extended further. It was necessary to determine of what species this was of the larval stage. Following the experiments of the Italian Helminthologist, Ercolani, some of these larvæ were fed to a duck in the hope that the adult forms might make this bird a temporary or forced host at least long enough to mature. The excreta were examined prior to the feeding to see whether the duck might already be harboring similar parasites. None such were found. After about ten days, typical trematode eggs appeared in the excreta, and upon examination the intestines of the duck yielded about forty mature holostomidæ. This seemed a clear case of established identity. These forms had been noted but once before by Ercolani, and he had limited his observations to a few external points. These mature forms were then subjected to a similar morphological study, and because of the excellent material afforded, their anatomy and histology was determined with more success than is usual in dealing with such forms. Ercolani had wrongfully classified the form, and comparison with all the determined species showed this form to be a new one to science.

It was now hoped that the eggs found in the excreta might be watched in their development until they should as larvæ enter again the body of a snail and so complete the life-cycle of this trematode. The early segmentation was followed and its development toward a ciliated embyro noted, but it was not possible to follow the cycle farther. There is, however, from what we know of related forms, no special difficulty in bridging over this gap.

The results of the observations briefly summarized are these:

(1.) The determination of the anatomy of the tetracotyle larvæ.

(2.) The identity of this larvæ with a definite adult form of holostomum.

(3.) The determination of the anatomy and histology of this adult form.

(4.) The development of the eggs through the earlier stages of segmentation toward the formation of a ciliated embyro.

(5.) The correct placing of two forms (the larval and the adult) in the systematic arrangement of the trematodes.

[The detailed accounts of these observations, together with the drawings of all the structures described, are intended to appear in a published report later.]

Abnormal Incisor Growth of Rodents. C. E. Newlin, Indianapolis.

The omnipotent and omniscient hand of Mother Nature in providing for the varied wants and conditions of her children is nowhere better shown than in the constant and rapid growth of the incisor teeth of that order of little animals known as Rodents. Securing their food as they do by gnawing the hard bark, roots and nuts, their incisor teeth would soon be worn off to the very gums if it were not for the constant and rapid growth of these teeth. To show the rapidity of this growth is the object of this short paper.

It is no unusual thing to kill a squirrel or rat that by some accident has lost one of its incisor teeth. The opposing tooth, having no direct opponent to hold the food against it, often becomes abnormally long, often becoming very inconvenient to the owner in procuring its food. But usually the remaining tooth is brought into more or less use in procuring food, and is thus kept ground off to some extent, though I have sometimes found them quite long.

I have in my possession the skull of a Ground Hog, *Actomys Monax*, which shows such abnormal growth of all the incisors that I thought it might be of interest to the members of the Academy to call their attention to it.

The specimen that was the unhappy possessor of this skull in life was killed in a meadow on a farm near Shannondale, Ind., by Wm. T. Beck, now of Crawfordsville. He noticed his dog attacking some animal and going to its assistance found a Ground Hog offering poor resistance, and killed it by crushing the back of its head with his fork handle. Picking it up he noticed the two white tusk-like teeth projecting up over its nose. He cut its head off and took it to his woodshed and laid it upon a cross-beam over the door, and there the insects did what they could to preserve it by denuding it of its flesh. The teeth became loose, and in handling it the longest lower incisor dropped out and was broken. But I had a dentist carefully reproduce the part broken off with paste dentine, and wired the skull together. Otherwise it is just as it was when it thwarted his wood-chuckship in his struggle for existence. The right lower incisor is 3¾ inches long and correspondingly abnormally large in circumference. The lower incisor on the left side seems to have come in contact with the left upper incisor to some extent and did not grow so long. Both lower incisors extend up over the nose and securely locked his mouth, so that securing food was almost impossible. This was possible at all only on the left side and then only by separating his lips and biting off clover leaves, etc., with his back molar teeth. He had done this so long that the lips on that side remained wide apart, exposing all the back teeth, while the lips on the opposite side grew fast together and fast to the gums.

The left upper incisor grew in a circle, and when it came to the roof of the mouth became deflected until it found the suture of the palatal surface of the superior maxillary and passed through this up into the nasal passage and continuing its growth in the circle turned downward through this bone again into the mouth, completing over a circle and a quarter. The pleasant sensations he must have experienced while this growth was taking place must have been entertaining at least. The right upper incisor was forced to the right and missed the superior maxillary, and performed the same circular growth between the lip and gum. Each of the upper incisors are about 3½ inches long. The right one shows by the abrasions on it where it came in contact on its side with the lower incisor in the earlier stages of its abnormal career, but the contact was not sufficient to arrest its growth.

The animal was weak and almost starved when killed, and I think no animal could live long on the small amount of food that could be procured after these teeth reached one-half their present length. Thus I reason that the growth of the incisor teeth of rodents must be very rapid, and I would place the time that elapsed after the accident happened this unfortunate creature, by which his teeth were so dislocated as not to oppose each other, and the time that he was killed could not have been more than a few months, under a year at the farthest. This rapid growth seems to be reasonable, too, when I consider the growth necessary to counteract the tremendous wear to which the incisors of a rodent are subjected. If this were not so, many a little fellow would find himself frequently in the condition of the fabled rat that gnawed the file.

THE BOBOLINK (DOLICHONYX ORYZIVORUS) IN INDIANA. BY A. W. BUTLER.

The Bobolink was one of the fanciful birds of my boyhood. The accounts of it which came to me, both by tongue and pen, interested me greatly. I longed to see the bird and hear him sing. At first I concluded it was to be found abundantly—a characteristic feature of the landscape—each spring. Year after year I watched for it, but it did not come. I consulted others who enjoyed the company of birds, and learned they had not seen it. The natural conclusion was I must see it in some other locality; but finally, before my purpose was carried out, it came to me. I saw my first Bobolink in the spring of 1881. On May 5, when walking by a timothy meadow within the town of Brookville, Ind., I saw a half dozed males, dressed in their distinctive colors, arise, one after another, from the

grass, only to alight again beneath its waving tops. They were busily feeding, and sang no song. Up to this time there were perhaps not a dozen localities within a hundred miles of the Ohio River, throughout its entire length, from which it had been reported. Dr. F. W. Langdon had noted it in the vicinity of Cincinnati, Ohio; Dr. Rufus Haymond had found it in Franklin County, Ind.; Dr. A. W. Brayton gave it from Marion County. All these records were of its spring occurrence. Since then almost every spring it has been met with, in limited numbers, in the southern part of this State, but records of its occurrence in fall are very few. At that time it had been found to range in summer as far north as Quebec, towards the coast, and in the interior to the Saskatchewan (latitude 60°). In winter it passed south beyond the United States, reaching the West Indies, Central America, Galapagos Islands, and going as far south as Bolivia, Argentine Republic and Paraguay. It was said to reach west, during the period of its visits to our land, to Kansas and Dakota. But continued explorations have shown its presence in Utah, Nevada, Wyoming, Montana, also, and, more recently, Maj. C. E. Bendire has ascertained its occurrence in British Columbia, thus extending its range to the Pacific Coast. To the form ranging from Kansas and Dakota westward the subspecific term *albinucha* has been given. Dr. T. M. Brewer gave its breeding range from latitude 42° to 54° North; that is to say, from the southern boundary of Massachusetts, New York, Michigan and the latitude of Chicago northward to the extent of its range. In the early days of this country's history they doubtless were found in great numbers, as summer residents, in natural meadows, prairies and marshy places—such open land as was suited to their needs for housekeeping and for food supply—in the region indicated. They did not frequent the timbered districts. The forest lines were barriers to them; but as the woods of the more level region gave place to grain and then to grass, the territory over which they might spend the summer extended, while, on the contrary, in certain districts, where the forest growth encroached upon the prairies, the area of breeding ground was correspondingly lessened. Their summer range, at least in Indiana, Ohio, Michigan and Illinois, has been much misunderstood. Where it is found no general statement as to its distribution can be made, for it appears to be quite irregular; indeed, in many localities, exceedingly local. The extent of its distribution and numbers depends primarily upon the area of land suitable for its occupation. The extension or restriction of the latter has a corresponding effect upon the former.

In order that its local distribution and the effect of man's occupation upon its history may be made clearer I submit the results of some investigations I have been permitted to make.

I shall refer first to Michigan. It is common and breeds at Port Sanilac (W. A. Oldfield). Common and breeds at Bay City (N. A. Eddy). Breeds commonly at Saline (Norman A. Wood). Common summer resident; breeds at Belle Isle (Louis Fites). Common; breeds at South Ogden (Mrs. H. C. Somes). Raisin, Lenawee County; common, breeds (Alfred W. Comfort). Common, breeds, Ganges, Allegan County (David Lewis). Brant, Saginaw County, common, breeds (W. De Clarenze). Ann Arbor; common, breeds (A. B. Covert, L. T. Meyer, James Savage, F. L. Washburn). St. Clair County; common, breeds (Stephen A. Warnie). Windmill Point; common, breeds (N. J. R. Kennedy). Common; breeds, Battle Creek (Nathaniel Y. Green). Manchester; common, breeds (L. Whitney Watkins).

Abundant summer resident at Albion, Calhoun County, and St. Joseph, Berrien County (O. B. Warren).

Mr. R. C. Alexander, Plymouth, says that they have been there for fifty years and steadily increased in numbers, more common than usual this summer (1894). Evenly distributed in this locality. Breeds abundantly.

Prof. A. J. Cook says they were not found in central Michigan until within a few years (Birds of Mich., p. 101).

I can not tell at how many of these localities it has been continuously a breeder as at present. The following localities report a change: At Agricultural College, Ingham County, they were first seen in 1874 (A. J. Cook). At Locke they were rare until 1874 and very common in 1875 (Dr. H. A. Atkins). First seen in Monroe County in 1872 (Jerome Trombley). Grand Rapids, Kent County; never common, but two or three pairs breed near this city (Stewart E. White, 1888. Benzie County: Never seen until late years; rare (Wm. G. Voorheis, 1892). In the Northern Peninsula, Prof. Cook says, upon the authority of Mr. E. E. Brewster of Iron Mountain, Dickinson County, that it occurs rarely at that place. In 1895, Mr. O. B. Warren saw them for the first time at Palmer, Marquette County. They remained and bred.

In Illinois, Mr. Robert Ridgway says it breeds only in the northern part of that State (Birds of Ill., Vol. I, p. 309).

My own experience is that in the vicinity of Chicago, Illinois, it is the most abundant I have ever seen it. This is especially true in the vicinity of South Englewood and southeast of Grand Crossing towards Indiana. The reports of Messrs. J. O. Dunn and C. A. Tallman from the last mentioned neighborhood and of Mr. Eliot Blackwelder from the vicinity of Morgan Park corroborate my experience. Mr. Blackwelder in 1894 wrote me that it was increasing yearly and was excessively numerous that year.

In Indiana, Mr. L. T. Meyer has assured me of their abundance in the northern part of Lake County. Mr. C. E. Aiken tells me they were abundant in that county in 1871. Mr. J. Grafton Parker and Mr. H. K. Coale have noted them as common in that county. In 1886 Mr. R. B. Trouslot told me it was common in Porter County. Summer resident near Michigan City, Laporte County (J. W. Byrkit). Laporte County: Abundant; breeds (Chas. Barber). Mr. Ruthven Deane reports them abundant and apparently breeding at English Lake, Starke County. Marshall County: Common (A. I. Mow). Dr. Vernon Gould, of Rochester, Fulton County, informs me that upon the prairies and open marshes in the western part of that county the Bobolink is found quite common in its favorite localities and has been for fifty years. In the eastern half, or timbered section, it is not often seen. He does not think there has been any perceptible change as to numbers since the country was settled. Mr. Victor H. Barnett reports them present at Francisville, Pulaski County, June 11, 18, 19 and 20, 1896, and thinks they breed sparingly. In 1891, Hon. R. Wes. McBride, a close observer, wrote me that the Bobolinks were entirely unknown in Elkhart County. That he had not seen one there nor had any one else to his knowledge. In 1895, Mr. Chancey Juday wrote that he saw a number near Millersburg, that county, the week ending June 22. In Kosciusko County, Mr. L. H. Haymond, informs me they were first observed in 1872 or 1873. The next summer a few pairs bred in a swamp within the city limits of Warsaw. They have increased in numbers yearly. At Fountain Spring Park (Winona) many pairs now breed annually. I, myself, have for two seasons, found a great company in the meadow west of the assembly ground in the latter part of June and early July. In 1894, a pair of Bobolinks were discovered to have built their nest on ground often occupied for shooting tournaments. The traps were so placed that the nest was between them and the shooters. All the firing was over the nest. At first the birds were very much frightened by the noise. The female left the nest at the beginning of the shooting, returning when the first match was shot. She left again when the next match began. After some time, however, she returned to her nest and remained there until the close of the shooting. Hundreds of shots were fired over her, yet she sat quietly on her nest through it all. Mr. J. E. Mow says they are common and breed at Millwood in Kosciusko County. Mrs. Jane L. Hine, of Sedan, Indiana, wrote me in 1892, that the first Bobolinks appeared near Kendallville, Noble County, in 1883. She saw them there the next year, June 4, 1884. In 1885 they appeared two and a half miles east of the DeKalb and Noble County line. In 1886, at Sedan, two miles farther east, she saw three males that spring. There was more of them in 1887 and increased after that. In 1888 the people of a neighborhood

six miles east of Sedan were telling of their new bird, the Bobolink. Mr. McCord, who has been much upon the Auburn and Fort Wayne road, saw his first Bobolink there in 1887.

According to Hon. R. Wes. McBride, Bobolinks first appeared about Waterloo, Dekalb County, about 1880. In 1891 he wrote me they were one of the most common summer residents in Dekalb, Steuben and Lagrange counties, and in a paper before this Academy (Proc. 1891, p. 167,) he reiterates his remarks in substance, and adds: "It is still very rare in Elkhart County, only a short distance west, with the apparent conditions not materially different." In 1886 Mr. J. O. Snyder informed me that pairs remained all summer at Waterloo. In 1887 he said it was uncommon and bred. In 1888 he noted it as becoming more common each year. In 1894 Mr. J. P. Feagler said, in speaking of Dekalb and Steuben counties, the rate of increase is about ten per cent. a year. In 1889 Mr. C. A. Stockbridge, of Ft. Wayne, wrote me they were found in Allen County all summer, and he thought they bred. In 1893 Mr. W. O. Wallace wrote me it was a common summer resident at Wabash. It was first noticed there about 1887, when he saw two males. From that time they have been increasing until they are now one of the commonest meadow songsters. Dozens of persons—adults—asked him what the new bird was. Upon their describing it he recognized their new acquaintance as the Bobolink. Mr. D. C. Ridgley first noted it breeding in Wabash County about 1891. Since then Mr. Wallace has often caught young unable to fly, but has never found their nests. (Birds of Wabash County, Proc. I. A. S. 1895, p. 153.) Mr. F. E. Bell reports it as common and breeding at North Manchester.

In 1892 Prof. E. E. Fish, Buffalo, New York, wrote me that several years ago he traveled slowly through several of the northern counties of Indiana without once seeing a Bobolink. He adds, "but they now sing in the meadows near Logansport, and doubtless they nest there, as they remain so late in the summer." Prof. A. H. Douglass, of Logansport, has recently written me that he has observed these birds for a number of years. Their numbers have increased steadily every summer. They breed there now in almost every timothy meadow. He adds: "It is a great joy to me during the latter half of May and the month of June to drive into the country and see them so abundant where there were none a few years ago. In some meadows last year (1896) there were more Bobolinks than Meadow Larks." They were first reported as migrants from Carroll County in 1884 by Prof. B. W. Evermann. Mr. Sidney T. Sterling says the first of these birds he saw in that county was in 1891. That summer two pairs remained about a wet place in a timothy meadow. As they remained so constantly near the same place, he concluded they were nesting. They disappeared about harvest time, to

be seen no more until the following spring, when they returned to the same place. In 1893 the field was put in wheat, and the birds were not seen any more. At Lafayette it is rare, and I can not learn that it is a summer resident, or breeds. (L. A. and C. D. Test, R. R. Moffitt). Mr. J. E. Beasley, Lebanon, says that the first of this species he saw in Boone County was in 1869. There were three males. They have been increasing since that time. While the greater part seen are migrants, there are always a few pairs that breed. I myself have seen them during the spring migration in Howard County, but do not know that they have been observed to breed there. Mr. A. B. Ghere says they breed commonly in Clinton County. In 1889 Mr. J. R. Slonaker reported them common at Terre Haute, and added they had been noticed to breed there for the past three years only. Mr. A. H. Kendrick reports them as breeding near Ellsworth, Vigo County, in 1896. In 1887 Dr. A. W. Brayton informed me that he had found them breeding upon the grounds of the Institution for the Deaf and Dumb within the city of Indianapolis. In 1889 Mr. W. P. Hay reported them breeding at Irvington, adding, they had been scarce until the last two years. Mr. Roy Hathaway informs me they breed in Jay County, near Red Key. In 1886 Mr. G. G. Williamson reported one from Delaware County, June 3, and added they bred there. In 1890 he notes it as not common; breeds. In 1892 he informed me the Bobolink had surprised him. He writes: "He has come and brought all his friends and relatives with him. He has always been a scarce bird hereabouts before this. But this time he is actually abundant. Every suitable meadow furnishes one or more, and their music boxes are in the best of order."

The first record I have from Wayne County is from Dr. Erastus Test, Purdue University, Lafayette. He tells me he saw a number of Bobolinks there from 1883–6, and especially refers to them in the vicinity of Earlham College, near Richmond. They were next reported from that county in 1888 by Messrs. H. N. McCoy, W. C. DeWitt and Fred. M. Smith, of Richmond. They noted them as remaining as late as July 1st. I have reports from there almost every year since. In 1891 I found it near the southern boundary of Wayne County. I called the attention of some of the members of the Wayne County Horticultural Society to this occurrence. As a result I received a report for that year from Mr. Walter S. Ratliff. This was the first time he had observed them. There were only three. They were seen about the edges of the same meadow every day until July 21st. He says they bred. In 1892 they returned to the same farm. There were nine. They paired and again nested in the meadows. Young were noted a mile farther north. July 20th they left. In 1893 these birds came again in larger numbers

than before. In 1896, however, they remained but a few days in the locality formerly frequented, and did not breed there.

Bobolinks have been reported from Decatur County for a number of years. Prof. W. P. Shannon found them June 1, 1895, and a pair July 2, 1896. He is inclined to think it breeds.

Thus it can readily be seen how the breeding range of this species has been extended within recent years through the encroachment of man upon the original forest area of our region until it now occupies in summer near two-thirds of the State. By this also its range during the breeding season is extended southward about three degrees. In addition to those noted, the Bobolink has been reported from the following counties in this State, in most of which it probably occurs as a migrant: Knox—Bicknell (E. J. Chansler), Vincennes (Angus Gaines); Monroe—Bloomington (W. S. Blatchley, C. H. Bollman, B. W. Evermann, G. G. Williamson, E. M. Kindle); Bartholomew—Newbern (U. F. Glick); Fayette—Connersville (J. E. Rehme); Dearborn—Moore's Hill (C. W. Hargitt, G. C. Hubbard); Grant—Marion (H. N. McCoy); Putnam—Greencastle (J. F. Clearwaters, Jesse Earlle); Henry—Dunreith (E. Pleas); Brown—Spearsville (Victor H. Barnett); Madison—Anderson (Charles P. Smith); Johnson—Trafalgar (Miss Harriet Jacobs).

It is interesting to note the summer range of the Prairie Horned Lark, *O. a. praticola* and of the House Wren (*T. aedon*), and see how nearly they coincide in this State with the summer range of the Bobolink.

In Ohio, Dr. J. M. Wheaton (Report on the Birds of Ohio, 1882, p. 352) tells us: Dr. Kirtland gives it without comment, Mr. Read gives it as very abundant and breeding, and says that "years ago it was not found upon the reserve." Mr. B. F. Abell, of Welchfield, Geauga County, says that it was first observed in that place May 20, 1857. In the vicinity of Columbus, he states, it was unknown to old residents. He says: "I first saw them in May, 1857, when I obtained a specimen which, with two or three others, was perched upon a tree upon the bank of Alum Creek. Since then they have increased in numbers and, during the last six or seven years at least, a few have nested with us. They are also known to breed at Yellow Springs, about fifty miles south of west of this city." Dr. F. W. Langdon (Journal Cin. Soc. Nat. Hist., Vol. III, Oct., 1880, p. 224), the week ending July 4, 1880, observed a few birds only near Port Clinton, Ottawa County. Prof. E. L. Moseley reports it from the vicinity of Sandusky. In addition to those noted Prof. A. L. Treadwell, Oxford, O., and Mr. Charles Dury, Cincinnati, note it in their respective localities, where it is probably only found as a migrant.

It would seem that it is entirely probable before man commenced his warfare upon our forests and began to replace the trees with grass, the Bobolinks found suitable breeding grounds about the lower end of Lake Michigan, reaching indefinitely westward and possibly southward into Illinois. They extended over some six or eight counties of northern Indiana to the vicinity of Rochester, Fulton County, and a few of the southwestern counties of Michigan. From this center they seem to have spread out in all directions. It is probable that along Lake Erie, in Ohio, there were localities they also originally sought as summer homes, and from there have spread over quite a large part of that State. The data at hand is not sufficient to guide one very correctly in this regard. From southeast Michigan, however, more observations are available, and would indicate that even there the Bobolink is a recent advent. Whether or not they are of recent introduction into the Saginaw Bay region the evidence does not say.

Prof. W. W. Cooke and Mr. Otto Widmann give it as a summer sojourner at Jefferson Cisy, Mo. (Bull. No. 1, Ridgway Ornithological Club, December, 1883, p. 33). Dr. William C. Rives thinks it may breed in the Virginias (Cat. Birds of the Virginias, Proc. Newport, N. H., Soc., October, 1890, p. 69). These localities are slightly farther south than those I have noted. With these exceptions I have given the extreme southern points of their breeding range, and they are the fringing markers on the barriers of the breeding region. Capt. C. E. Bendire, in the second volume of his valuable "Life Histories of North American Birds," has recorded the unusual fact that the Bobolink breeds, in April, in small numbers, on Petite Anse Island, on the coast of Louisiana, and that it probably breeds rarely in Florida (Special Bulletin U. S. National Museum, Smithsonian Institution, 1895, p. 433).

The Bobolinks reappear on the southern border of the United States in April, and for about a month are very destructive to the planted rice. Then they move northward to their breeding grounds. This is true of the bulk. There are single birds which often push on ahead of the crowd—some of them at a very early date. April 4, 1890, I found a single male at Brookville, Ind. No others were seen until May 17. Dr. P. L. Hatch says it arrived in the vicinity of Minneapolis, Minn., April 5, 1870. (Notes on the Birds of Minnesota, First Rept. State Zoölogist, Geol. and N. H. Surv., June, 1892, p. 271.) In 1885 it first reached Mount Carmel, Mo., April 20. (U. S. Dept. Agriculture, Div. of Economic Ornithology, Bull. No. 2, Report on Bird Migration in the Mississippi Valley in the years 1884 and 1885, by W. W. Cooke, 1888, p. 160.) In 1885, also, Mr. C. H. Bollman found a single male at Bloomington, Ind., April 17. It was next seen there May 2.

I am convinced that the great bulk of these migrants pass up the Atlantic Coast and seek their summer homes in this region from the east or southeast. The migrants that are seen with us are exceedingly few compared with the immense numbers that frequent our Northern meadows and prairies. While it is true they migrate at night, yet we see neither the weary resting by day nor hear the noise of the winging hordes by night. In the East it is commonly said that their unmistakable voices come to the listener as one of the characteristic sounds of the warm nights in early May. Who has had such an experience among us? Strange as it may seem, the birds in their original breeding range, and in Southern Michigan generally, arrive as soon—and in some cases actually sooner—than they do in the localities farther south, where they more recently began to nest. It is further true that often the corresponding dates of first arrival, etc., of the schedule are as early—and not infrequently earlier—in the old summer home than they are in the localities southward, where they occur only as migrants. This may be another clew from which further investigation will derive a point tending to show the route of the migration of the bulk of the Bobolinks to these breeding grounds is farther to the eastward, and earlier, and not across the interior States of the Mississippi and Ohio Valleys.

While Bobolinks, singly or few in number, migrate very early, as heretofore stated, most of them are actually noted between April 27th and May 8th. This may in some years be a day or two earlier, in others a few days later. The date at which they have been noted as common in various localities in general may be said to range from May 1st to 15th. The males precede the females by from two days to two weeks, averaging at least a week earlier. They are the features of the early clover field as it comes into bloom. The blossoms of the small red clover (*Trifolium pratense*) and the Bobolink come together.

For reference I give at the end of this paper a synopsis of the reports received for the years 1885 to 1896, both inclusive. These reports include not only observations from Indiana, but also some reports from correspondents in Ohio, Illinois and Michigan. I desire to thank them all, and also to express my appreciation of the courtesies extended to me by Dr. C. Hart Merriam, Chief of the Biological Survey of the United States Department of Agriculture.

When the Bobolinks come north in the spring the males wear an attractive livery of black, with white and light brownish markings above. They are attired for the opera. Their exquisite songs and lively, cheery, droll ways which form a characteristic feature of the life of a locality where they abound are shown to please the other sex—to make them attractive to the females and not to please you and me. But in fact we do derive much enjoyment from their life and song.

Whether or not it is so, it seems that there are two or three males devoting themselves to every female. The latter, in their sparrow-like dress of yellowish and brown, are comparatively inconspicuous, and this may be the reason they seem so few. The days of courtship are soon over and the Bobolinks settle down to housekeeping. Often there are many pairs nesting close together. They prefer a sociable company. They nest in cloverfield, prairie, meadow or grassy marsh. Nest building is begun within a few days after arriving, usually about the middle of May. The full complement of eggs may usually be found in them by the first week in June. Some of the earlier laid sets are found far advanced the second week of that month, while between June 15th and July 5th the nests usually contain young. The nest is built of dried grass, flags or weeds loosely placed together and lined with finer dried grass. It is often, perhaps usually, built in a slight natural depression in the ground. Sometimes it is placed upon the level earth. In either case it is arranged so as to be concealed by the dead grass stems and growing blades. Often the nest is placed in a clump of clover or tuft of grass above the ground and fastened to the stems of the plant.

The average nest is four inches in outer diameter by two inches in depth; the inner cup is two and one-half inches in diameter by one and one-fourth inches deep (Bendire, loc. cit. p. 433). The eggs are ovate. The ground color varies from pearl gray or drab to reddish brown or cinnamon. They are irregularly spotted with different shades of brown, heliotrope and lavender. Almost no two eggs are marked alike. The average size is .83 by .62 inch.

By the middle of July the young are beginning to leave the nest and labor for themselves. The males in a surprisingly short space of time take on the plumage of the females, and the families form groups and many families unite, all attired in plain colors, living a quiet life until they begin their journey toward their winter homes. Many persons are not acquainted with the female, and when the attractive coat of the male changes to plainer hue they conclude the birds have gone. Hence many think the Bobolinks leave from the 20th to 30th of July. In some localities they perhaps desert more undesirable places and congregate in favorite spots, in others they remain about their homes. Most of them seem to leave about the middle of August, though it is much more difficult to get satisfactory statistics as to their fall movements in the northern States than of their spring migrations. That they often remain much later than the date noted, and well into September, is known. In 1890 Mr. H. N. McCoy sent me a Bobolink taken at Marion September 29. In 1891 the last was reported from South Ogden, Mich., September 2. In 1892 from Plymouth, Mich., September 12. In 1894

from Plymouth Mich., September 21, and from Cook County, Ill., September 24. In 1895 from Morgan Park, Ill., September 12.

During the spring migrations with us and throughout the breeding season the food of the Bobolink is largely insects. Naturally those species frequenting grass lands are chiefly preyed upon. As illustrations of this I may refer to the results of two investigations of their food at this season. Dr. B. H. Warren, of West Chester, Pa , examined the stomachs of twenty-seven specimens taken in Chester County, Pa., in May, 1879, 1880, 1882 and 1883, and found that eighteen fed exclusively on beetles, larvæ, ants and a few earthworms; five, in addition to insects and larvæ, showed small seeds and particles of gray vegetable materials, apparently the leaves of plants; the four remaining birds revealed only small black and yellow colored seeds. (Birds of Pennsylvania, second edition, 1890, p. 207.) In the early part of May, 1886, Mr. George L. Toppan, of Chicago, examined the stomachs of nine Bobolinks taken near Grand Crossing, Ill., not far from the Indiana line. Eight had their stomachs full of insects, while the ninth contained, in addition, a few worms. After the breeding season is over these birds turn their attention to the ripening grass seeds. They seem to be especially fond of the seeds of Hungarian grass. They are also said, in some localities, to eat the milky grains of the maturing corn. On the whole, their life with us may be said to be one of blessing and benefit, of happiness and good cheer. In the South, along the South Atlantic and Gulf coasts, how different are its portents. There they are winged destroyers, blighting the prospects of the results of man's labors. Dr. Merriam, in his report as Chief of the Division of Ornithology and Mammalogy of the United States Department of Agriculture for 1886, gives the results of his investigations of the destruction caused by the Bobolinks, locally known as "rice birds," among the rice-growing regions of the South. I take the liberty of giving the following extracts from a letter from Capt. William Miles Hazzard, of Annadale, S. C., one of the largest rice growers of that state, which is included in the above-mentioned report and will, better than anything else that I know, give an idea of the work of these birds among the rice fields.

"The Bobolinks make their appearance here during the latter part of April. At that season the plumage is white and black, and they sing merrily when at rest. Their flight is always at night. In the evening there will be none. In the morning their appearance is heralded by the popping of whips and firing of musketry by the bird minders in their efforts to keep the birds from pulling up the young rice. This warfare is kept up incessantly until about the 25th of May, when they suddenly disappear at night. Their next appearance is in a dark yellow plumage as the ricebird. There is no song at this time, but instead a chirp

which means ruin to any rice found in milk. My plantation record will show that for the past ten years, except when prevented by strong south or southwest winds, the ricebirds have come punctually on the night of the 21st of August, apparently coming from the seaward. All night their chirp can be heard passing over our summer homes on South Island, which is situated six miles to the east of our rice plantations, in full view of the ocean. Curious to say we have never seen this flight during the day. During the nights of August 21, 22, 23 and 24, millions of these birds make their appearance and settle in the rice fields. From the 21st of August to the 25th of September our every effort is to save the crop. Men, boys and women, with guns and ammunition, are posted on every four or five acres, and shoot daily an average of about one quart of powder to the gun. This firing commences at first dawn of day and is kept up until sunset. After all this expense and trouble our loss of rice per acre seldom falls under five bushels, and if from any cause there is a check to the crop during its growth which prevents the grain from being hard, but in milky condition, the destruction of such fields is complete, it not paying to cut and bring the rice out of the field. We have tried every plan to keep these pests off our crops at less expense and manual labor than we now incur, but have been unsuccessful. Our present mode is expensive, imperfect and thoroughly unsatisfactory, yet it is the best we can do. I consider these birds as destructive to rice as the caterpillar is to cotton, with this difference, that these ricebirds never fail to come."

Captain Bendire thinks it probable the decrease in the numbers of Bobolinks noticeable in their breeding range in some of the eastern states is due to this relentless warfare by the planters. That there is no decrease but rather a noticeable and continual increase in numbers and also in the gradual extension of their range in our region is the burden of the testimony I have been able to collect.

Name of Observer.	Place where observations were made.		When was it first seen?	About how many were seen?	When was it next seen?	When did it become common?	When was it last seen?	Is it common or rare?	Does it breed near your station?	Remarks.
1885.										
C. H. Bollman	Bloomington	Ind	†April 17 ‡May 2	1 1	May 5 May 4	May 22* May 17*				
Jane L. Hine	Sedan	"	May 7					Smr. resident Tol'bly comn		First appearance here.
1886.										
C. H. Bollman	Bloomington	Ind.	May 4	12-15	May 6			Common	No.	
B. W. Evermann	Bloomington	"	May 4	4	May 5			Not common	Migrant	
Jane L. Hine	Sedan	"	May 8	3	May 9			Common	Yes.	
LeGrand T. Meyer	Cedar Lake	"	May 4							
J. O. Snyder	Waterloo	"	May 2					Tol'bly comn		
G. G. Williamson	Bloomington	"	May 5	16	May 7		May 17			
G. G. Williamson	Muncie	"	June 3						Yes.	
Geo. L. Toppan	Grand Crossing	Ill.	†May 3 ‡May 4	6				Common Common	Yes. Yes.	
J. Grafton Parker	Grand Crossing Lake County	Ill. Ind	May 11					Common	Yes.	
Jerome Trombley	Petersburg	Mich.	†May 2 ‡May 10	1	May 3	May 10		Common	Yes.	
1887.										
LeGrand T. Meyer	Brunswick	Ind	Apr 27	7	April 28	April 28		Common	Yes.	
J. O. Snyder	Waterloo	"	May 3	2	May 7			Not common	Yes.	
J. E. Rehme	Connersville	"	May 2	Many.			May 4			
W. P. Shannon	Greensburg	"	May 2	2				Rare		
G. C. Williamson	Bloomington	"	May 1	7	May 4					
Jane L. Hine	Sedan	"					June 27			Becom's com.
Jerome Trombley	Petersburg	Mich.	May 1	2-3	May 3	May 5		Abundant	Yes.	
1888.										
Isaac Craft	Terre Haute	Ind.	May 13	1	May 18			Rare		
U. F. Glick	Newbern	"	May 4	5				Rare	Migrant	
Chas. Gough	Lafayette	"	May 6	1						
A. B. Ghere	Frankfort	"	May 1	23	May 2	May 2		Tol'bly comn	Yes.	
W. P. Hay	Irvington	"	May 5	6	May 9			Common	Yes.	

*Next seen. †Male. ‡Female.

Name of Observer.	Place where observations were made.		When was it first seen?	About how many were seen?	When was it next seen?	When did it become common?	When was it last seen?	Is it common or rare?	Does it breed near your station?	Remarks.
J. O. Snyder	Waterloo	"	†April 30	1	May 2					
W. C. DeWitt	Richmond	"	May 2	4	May 2			Tol'bly comn		
H. N. McCoy	Richmond	"	April 28	4	May 7	May 12	June 2			
Fred M. Smith	Richmond	"					July 1			
C. W. Hargitt	Moore's Hill	"	April 27	6	April 30					
G. G. Williamson	Bloomington	"	May 6	2	May 13		June 14			
W. P. Shannon	Greensburg	"	May 5	15					Migrant	
F. M. West	Greensburg	"								
LeGrand T. Meyer	Cedar Lake	"	April 28	20	April 28	April 29		Common	Yes.	
R. W. McBride	Waterloo	"	May 1	12				Common	Yes.	
Jane L. Hine	Sedan	"	May 5		May 6	May 8		Common	Yes.	
Ruthven Deane	English Lake	"	May 11		May 25	May 25				
Newell A. Eddy	Bay City	Mich.	†May 24	1						
N. Y. Green	Battle Creek	"	May 2	1	May 3	May 10		Common	Yes.	
F. L. Washbourn	Ann Arbor	"	May 5	Sev'l †	May 8	May 8		Common	Yes.	† May 8 † and ‡ ‡ common.
Stewart E. White	Grand Rapids	"	May 3	3	May 24			Tol'bly comn	Yes.	
1889.										
J. O. Snyder	Waterloo	Ind.	†May 7		May 7	May 7			Yes.	
J. R. Slonaker	Terre Haute	"	May 10	2	May 12	May 12		Common	Yes	
W. P. Hay	Irvington	"	May 6	10 12	May 9			Common	Yes.	
Herbert W. McBride	Waterloo	"	May 9	3	May 10	May 12		Common	Yes.	
Jane L. Hine	Sedan	"	May 13		May 14	May 14		Common	Yes.	
LeGrand T. Meyer	Cedar Lake	"	May 3	5	May 9	May 9		Common	Yes.	
Fred M. Smith	Richmond	"	May 6	2	May 9	May 9	July 1	Common		
W. C. DeWitt	Richmond	"	May 22	1	May 23	May 25		Not common	Migrant	
N. Y. Green	Battle Creek	Mich.	May 5	2	May 6	May 10		Common	Yes	
Geo. D. Sones	Ross	"	May 9	4				Common	Yes.	
Alvan H. Alberger	St Clair	"	April 30	1	May 7			Common		
Jerome Trombley	Petersburg	"	May 2	1	May 3	May 7		Abundant	Yes.	
Adolphe B. Covert	Ann Arbor	"	May 4	2	May 5	May 8		Common	Yes.	
1890.										
G. G. Williamson	Muncie	Ind.	May 11	2	May 12			Not common	Yes.	
Herbert W. McBride	Waterloo	"	May 3	3	May 7	May 8		Abundant	Yes.	
B. W. Evermann	Terre Haute	"	May 3	1	May 8			Rare	No.	
J. O. Snyder	Waterloo	"	†May 8	1	May 10			Common	Yes.	
R. R. Moffitt	LaFayette	"	May 5	1	May 10	May 10		Rare	No.	

A. W. Butler	Brookville	"	April 6	1†	{ May 17 { † and ‡ { May 4			Rare.	No.	
A. E. Reed	Millwood.	"	April 29	1	May 4			Rare	Yes.	
Edw. Hughes	Greensburg	"	May 6	12					?	
H. N. McCoy	Marion	"					Sept. 29			
Jas. Savage	Ann Arbor.	Mich.	May 3	3	May 4	May 11		Common	Yes	
W. G. Voorheis	So. Frankfort	"	June 10	1				Rare		
S. A. Warnie	St. Clair Flats	"	May 1	4	May 8	May 20		Common	Yes.	
R. C. Alexander	Plymouth	"	May 1	2	May 2	May 3		Common	Yes.	
Jerome Trombley	Petersburg	"	May 3	1†	May 5	May 15		Common	Yes.	May 6, flock 25 or 30 all †.
1891.										
Jane L. Hine	Sedan	Ind.	May 9	1	May 11	May 11		Common	Yes.	
W. S. Ratliff	Richmond	"					July 21	Rare	Yes.	
H. F. Bain	Drewersburg	"	May 1	3						
J. S. Mow	Millwood	"	April 29	1	May 9	May 16		Common	Yes.	
Ruthven Deane	English Lake	"	May 10	3	May 17	May 17				
A. I. and E. B. Mow	Argos	"	May 9	1	May 10	May 12				
Jerome Trombley	Petersburg	Mich.	April 28	1	May 1	May 9		Common	Yes.	
R. C. Alexander	Plymouth	"	†April 27	1	April 29	May 9		Tol'ably com	Yes.	
			‡May 17	2	May 18	May 18				
Harriet C. Somes	So. Ogden	"	May 20	2	May 25	May 25	Sept. 2	Common	Yes.	
David Lewis	Ganges	"	April 28	2	April 30	May 25		Common	Yes.	
A. W. Comfort	Raisin	"	April 28	1	May 1	May 10		Common	Yes.	
N. J. R. Kennedy	Windmill Point	"	May 20					Common	Yes.	
1892.										
G. G. Williamson	Muncie	Ind.	May 8	2				Common	Yes.	
Jessie Earlle	Greencastle	"	May 14	25	May 26	May 14	May 30	Common	?	
Jane L. Hine	Sedan	"	May 4			May 4	July 12	Common	Yes	
V. Gould	Rochester	"	May 2	4	May 5			Common	Yes.	
L. A. and C. D. Test	LaFayette	"	†May 7	1				Rare, S. R	?	
W. S. Ratliff	Richmond	"	May 4	9	May 5	May 5	July 30	Rare	Yes.	
Chas. Barber	LaPorte	"	May 2	4	May 4	May 5		Common	Yes.	
J. S. Mow	Millwood	"	May 10	3	May 6	May 28		Common	?	
A. I. Mow	Argos	"	May 10	3	May 13	May 13		Common		
L. T. Meyer	Ann Arbor	Mich.	May 1	8	May 2	May 2		Common	Yes.	
Jerome Trombley	Petersburg	"	May 2	2	May 3	May 5		Abundant	Yes.	
W. DeClarenze	Brant	"	May 2	1	May 2	May 24		Common	Yes.	
R. C. Alexander	Plymouth	"	April 27	1	April 30	May 1	Sept. 20	Abundant	Yes.	
David Lewis	Ganges	"	May 2	3	May 3	May 17		Common	Yes.	
Harriet C. Somes	So. Ogden	"	May 15	2	May 20	May 20		Common	Yes.	
Lois Fites	Belle Isle.	"	May 8	6	May 10	June 12		Common	Yes.	
N. A. Wood	Saline	"	May 2	1	May 3	June 26		Common	Yes.	
N. A. Eddy	Bay City	"	†May 13	sev'l				Common	Yes.	

Name of Observer.	Place where observations were made.		When was it first seen?	About how many were seen?	When was it next seen?	When did it become common?	When was it last seen?	Is it common or rare?	Does it breed near your station?	Remarks.
1893.										
W. S. Ratliff	Richmond	Ind.	May 6	10	May 7	May 6	June 13	....		
Geo. C. Hubbard	Moore's Hill	"	April 23	1						
V. Gould	Rochester	"	May 11			May 20			Yes.	
A. B. Ghere	Frankfort	"	May 5	20	May 6	May 6		Common	Yes.	
G. G. Williamson	Muncie	"	May 6	1				Common	Yes.	
Jesse Earlle	Greencastle	"	May 1	5				Common	No.	
Chas. Barber	Laporte	"	May 1	1	May 2	May 5		Abundant	Yes.	
A. L. Treadwell	Oxford	Ohio	May 14	4						
L. Whitney Watkins	Agl. College	Mich.	May 3	2	May 6	May 9		Common	Yes.	
John Sinclair	Thunder Bay Id.	"	May 20	2	May 21	May 21		Common	Yes.	
Harriet C. Somes	So. Ogden	"	May 10	2	May 12	May 14	Aug. 5	Common	Yes.	
David Lowrs	Ganges	"	April 29	1	May 1	May 15		Common	Yes.	
R. C. Alexander	Plymouth	"	April 27	1	April 28	May 4		Common	Yes.	
W. H. Munson	Hillsdale	"	May 1	3	May 5			Common	Yes.	
Jerome Trombley	Petersburg	"	May 1	2	May 2	May 9		Common	Yes.	
1894.										
E. Pleas	Dunreith	Ind.	May 16	1						
E. J. Chansler	Bicknell	"	May 3	2	May 7	May 10	May 24	Not common	No.	
V. H. Barnett	Spearsville	"	May 3	1	May 12	May 15		Rare		
W. O. Wallace	Wabash	"	April 27	1	May 1	May 12		Abundant	Yes.	
A. B. Ghere	Frankfort	"	May 5	1	May 6	May 6		Common	Yes.	
Chas. Barber	Laporte	"	April 27	1	April 28			Abundant	Yes.	
J. P. Feagler	Waterloo	"	April 30	3	April 1			Common	Yes.	
A. L. Treadwell	Oxford	Ohio	May 7	1						
E. L. Moseley	Sandusky	"	April 28	1	May 3					
L. Whitney Watkins	Manchester	Mich.	May 2	2	May 3	May 11		Common	Yes.	
R. C. Alexander	Plymouth	"	April 30	3	May 1	May 6	Sept. 21	Common	Yes.	
N. A. Eddy	Bay City	"	†May 6	1				Common	Yes.	
Harriet C. Somes	So. Ogden	"					Aug. 5			
Eliot Blackwelder	Morgan Park	Ill.	May 5	8	May 6	May 6		Common	Yes.	
J. O. Dunn	S. Chicago	"	May 1	1	May 5	May 16	Sept. 24	Common	Yes.	
Alex. Black	Lake Forrest	"	May 4	1						
1895.										
Jane L. Hine	Sedan	Ind.	April 30		April 30			Common	Yes.	
A. B. Ghere	Frankfort	"	May 17	1	May 18	May 21		Common	Yes.	
V. H. Barnett	Spearsville	"	May 1	3	May 2	May 1	May 9	Tol'ably com	No.	

Harriet Jacobs	Trafalgar	"	April 29		2	April 30	May 15		Common	?	
E. J. Chansler	Bicknell	"	April 29		2	April 30		May 19	Not common	No.	
E. J. Chansler	Bicknell (Fall)	"	Sept. 9		4	Sept. 10	Sept. 11		Common	No.	
Roy Hathaway	Redkey	"	May 2		3	May 4	May 7		Common	Yes.	
W. P. Shannon	Greensburg	"	May 8		6	May 20		June 1	Tol'ably com	?	
E. L. Moseley	Sandusky	Ohio	April 25			April 27					
R. C. Alexander	Plymouth	Mich.	April 9		3	April 30	May 2		Abundant	Yes.	
N A Eddy	Bay City	"	May 4	2†	14				Common	Yes.	
T. L. Hankinson	Agl. College	"	May 2		1	May 4	May 4		Tol'ably com	Yes.	
W. DeClarenze	Brant	"	May 2		5	May 5	May 5		Common	Yes.	
O. B Warren	Palmer	"	June 2		1†	June 3	June 9		Rare	Yes.	First occurrence here June 9, 2† 24.
C. A. Tallman	Chicago	Ill.	May 4		20	May 5	May 5		Abundant	Yes.	
Eliot Blackwelder	Morgan Park	"	April 30		2	May 1	May 1	Sept. 12	Abundant	Yes	
1896.											
W. P. Shannon	Greensburg	Ind.	April 26		7	April 27	May 1	July 2	Tol. common		A pair July 2, 1896.
J. P. Feagler	Waterloo Golden Lake	" "	April 27		1	April 29	May 29		Common	Yes.	
Jane L. Hine	Sedan	"	May 6				May 5		Common	Yes.	
Mrs. L. M. Sniff	Angola	"	May 1			May 4					
F. E. Bell	N. Manchester	"	May 3		6	May 5	May 8		Abundant.	Yes	
W. S. Ratliff	Richmond	"	April 28		1	April 30			Rare	Yes.	Here only 2 or 3 days; did not nest with us.
A. H. Kendrick	Ellsworth	"	May 2		1	May 4	May 15		Med. common	Yes. ?	
A. W. Butler	Brookville	"	May 2		1				Rare	No	Only 1 seen.
E. J. Chansler	Bicknell	"	April 28		1	May 4					
W. B. Van Gorder	Knightstown Carthage	" "			2 3	June June			.....		
V. H. Barnett	Francisville	"	May 1		1	May 6	May 1	June 20	Tol. common	Yes.	
S. W. Collett	Upland	"	May 3								
A. B. Ulrey	S.pt. Kosciusko C.	"						Aug. 13			6 or 8 seen.
Chas Barber	Laporte	"	April 28		1	May 1	May 9		Common	Yes.	
C. A. Tallman	S. pt. Chicago	Ill.	May 2		25	May 5	May 2		Abundant	Yes.	
E. Blackwelder	Morgan Park	"	April 27		1	April 28	April 29		Abundant	Yes	
E. L. Moseley	Sandusky	Ohio.	April 26		1	April 27					
L. W. Watkins	Manchester	Mich.	April 26		1	April 28	May 1		Common	Yes.	
E. B. Schrage	Pontiac	"	April 20		1	April 30	May 6		Common	Yes.	
T. L. Hankinson	Agricul'l College	"	April 30		1	May 1	May 1		Common	Yes.	
W. E. Mulliken	Grand Rapids	"	May 9	Many		May 1	May 1		Common	Yes.	
R. C. Alexander	Plymouth	"	April 26		1	April 27	April 30		Abundant	Yes	
Dr. W. DeClarense	Brant	"	May 1		4	May 2	May 7		Common	Yes.	

THE BIRDS, OUR FRIENDS. BY E. J. CHANSLER.

SOME ADDITIONS TO THE INDIANA BIRD LIST, WITH OTHER NOTES. BY A. W. BUTLER.

The reports upon the migration of birds for the past year have not all been received; consequently the notes which I had hoped to report at this time will not all be given. What I have to say will be quite short. The facts, though few, are interesting and of much importance to Indiana ornithology. These include the addition of two species to the list of the birds of the State; also notes upon other species which are of rare occurrence or in other ways worthy of attention at this time.

Xanthocephalus xanthocephalus (Bonap.) Yellow-headed Blackbird.

Reported by Mr. C. A. Tallman from Cook County, Ill. It was first seen May 9, 1896, when two were noted; next observed May 16, and became common the same day. He found them nesting in a swamp about seven miles west of Morgan Park, and also at Mud Lake, on the Illinois and Indiana line. Their breeding habits are very similar to those of the Red-winged Blackbird.

Ammodramus henslowii (Aud.) Henslow's Sparrow.

Not common in Cook County, Ill. The first one the past spring was seen April 19; next noted April 25, when it was as numerous as it became; breeds. (C. A. Tallman).

Arenaria interpres (Linn.) Turnstone.

May 23, 1896, Mr. Eliot Blackwelder and Mr. C. A. Tallman, of Chicago, noted two Turnstones at Wolf Lake, in Indiana. They were in company with a miscellaneous flock of small Sandpipers. They were again seen June 9. I am informed upon the same authority that Mr. F. M. Woodruff has taken specimens of this species in Cook County, Ill.

Dendroica discolor (Vieill.) Prairie Warbler.

Mr. J. E. Beesley mounted a female that was taken at English Lake, Ind., June 14, 1896. It is now in the collection of the State Museum in the State House, Indianapolis.

Ampelis garrulus Linn. Bohemian Waxwing.

I am informed by Mr. J. E. Beesley that one spring, about forty years ago, he took nineteen Bohemian Waxwings in one day near Indianapolis. They were all in one flock, and were flying forward and backward over the river, catching insects, after the manner of Flycatchers.

Protonotaria citrea (Bodd.) Prothonotary Warbler.

Mr. Beesley informs me that some years ago he obtained a pair of these warblers on the farm formerly owned by Judge Terhune, three or four miles from Lebanon, Ind.

Buteo borealis harlani (Aud.). Harlan's Hawk.

This hawk is also known by the names Black Hawk and Black Warrior. There is a specimen of this rare species in the possession of Mr. R. B. Williams, who mounted it, at Lebanon, Ind. The bird was obtained in Perry Township, Boone County, Ind., in September, 1887. It was shot and its wing broken by Mr. W. H. Moler. He brought it alive to the present owner. The following are the measurements taken from the mounted specimen: Length, 24¾ in.; wing, 16½ in.; tail, 9½ in.; culmen, 1¼ in.; tarsus, 2⅜ in.; bare tarsus, 1⅜ in.; middle toe, 1½ in; claw, ⅞ in. This is the first record of its occurrence in the State. It had previously been taken in Illinois, where Mr. C. K. Worthen shot one of a pair on the Mississippi River, near Warsaw, Hancock County, in March, 1879. There is in my collection a specimen taken several years ago in Cumberland County, Ill., and presented to me by Mr. W. S. Everhart, of Toledo, Ill.

Fregata aquila (Linn.). Man-o'-War Bird.

The past fall I had the pleasure of seeing in the office of Mr. J. E. Beesley, at Lebanon, Ind., a fine specimen of a young male of this bird. He informed me he received the specimen in the flesh July 15, 1896, from Mr. W. I. Patterson, Shelbyville, Ind. It was killed the day before he received it (July 14), near that city. The following are the measurements taken from the mounted specimen: Length, 3 feet; wing, 2 feet; tail, 16 in.; depth of fork, 7 in.; culmen, 4¼ in. This is a bird of the tropical and subtropical seas. Its occurrence with us is wholly accidental. This is its first record for our State, although Mr. Robert Ridgway has previously reported it from Ohio. (Man. N. A. Birds, 1887, p. 83.)

Numenius longirostris Wils. Long-billed Curlew.

A mounted specimen of this bird was seen in the possession of Mr. Fletcher M. Noe, of Indianapolis, Ind., the past summer. He told me it was taken by Herman Eckert in a swamp near Jasper, Dubois County, Ind., April 2, 1896. The mounted specimen showed the following measurements: Length, 21 in.; bill, 5¼ in.; wing, 10 in.; tail, 4 in.; tarsus, 2¾ in.

Ardea cærulea (Linn.). Little Blue Heron.

Reported by Mr. E J. Chansler from Bicknell, Knox County, April 18, 1896. He says they are not uncommon in that vicinity in summer, though he does not think they are now so numerous as they were before they began to drain the ponds and swamps.

Falco peregrinus anatum (Bonap.) Duck Hawk.

In the State Museum in the State House at Indianapolis is a Duck Hawk taken in Boone County, Ind., May 14, 1896. (Beasley).

Anas penelope Linn. Widgeon.

Mr. Ruthven Deane wrote me of the capture of the fourth specimen of the European Widgeon in this State at English Lake in the spring of 1896. This is the eighth record of this species from the interior of the United States. It was killed on the marshes of the English Lake Shooting and Fishing Club by Mr. John E. Earle, of Hinsdale, Ill., March 23d last, and is now in Mr. Earle's possession. (The Auk, Vol. XIII, July, 1896, p. 255).

Ammodramus sandwichensis savanna (Wils.). Savanna Sparrow.

Mr. J. E. Beasley mounted a specimen of this sparrow, a female, which was killed at English Lake, Ind., June 14, 1896. The specimen is now in the collection of the State Museum.

Peucæa æstivalis bachmanii (Aud.) Bachman's Sparrow.

September 22, 1896, I found a specimen of this species three miles north of Brookville. It was seen along a rail fence, and tried a part of the time to keep hidden behind a rail. It was very tame and unsuspicious. Often would squat upon the bare ground or in the short grass and remain there motionless for some time. I was within an arm's length of it quite frequently, and saw it very distinctly a number of times, as I followed it along the fence. This is its first record for the White Water Valley, and, indeed, for southeastern Indiana.

BROOKVILLE, IND., Dec. 29, 1896.

Some Interesting Bones. By M. B. Thomas.

[Abstract.]

In October, 1896, there came to Crawfordsville a man by the name of Henry Patterson with a large wagon load of bones. These were extravagently described in handbills and attracted many visitors.

They were studied by the author and Prof. D. Bodine. Afterwards by Dr. E. E. Cope, with the aid of photographs. The bones were from some recent finback whale, but they made a profitable exhibition for their owner.

The Hydrographic Basins of Indiana and Their Molluscan Fauna. By R. Ellsworth Call.

For the purposes of this paper the State of Indiana is regarded as being divided into ten major hyrographic basins, as shown in the accompanying map. Of these the largest is the basin of the Wabash; the smallest the basin of the Patoka. Some of the waters of the State debouche into the Atlantic through the great lakes; others find their way to the gulf by way of the Illinois and Mississippi, still others reaching the same destination by way of the Ohio and Mississippi. Of these two major systems of drainage the latter is by far the most important.

Waters of the Atlantic Drainage.—In the northeastern part of the State is a considerable area of country, drained by the Maumee, itself a stream formed by the St. Mary's and St. Joseph rivers, and emptying into Lake Erie. Of the surface features of this small basin more will be said in the section devoted to the physiographic features of the various regions.

The second and third sub-drainage areas of northern Indiana contribute their waters to Lake Michigan; one, the largest, through the St. Joseph's River, the second of that name within the State; the other, the smaller, has no large streams and is directly drained into Lake Michigan. Between the two last named lies the upper portion of the Kankakee River, a considerable stream, which flows into the Illinois.

Waters of the Gulf Drainage.—More than nine-tenths of the State's area is directly contributary to the Ohio through the remaining six basins which we have found it convenient to establish. Nearly all of this vast territory is drained by the Wabash and its two principal tributaries, the east and west forks of the White River. Next in order of size come the Ohio, the Whitewater and the Patoka, the latter, however, tributary to the Wabash directly.

Surface features.—The northern region of Indiana is entirely within the region of ancient glaciation; its surface is characteristic of the drift areas. It is characterized by streams which are almost entirely in glacial debris, sand, gravel, boulders and clay variously contributing to the bottom features of the several streams; in the low-lying and imperfectly drained prairie regions are many lakes of varying areas, as the seasons are wet or dry, and of very great differences in their comparative sizes. These lakes are, for the most part, shallow, with more or less sandy, or gravelly, or bouldery, bottoms and shores. An abundant marshy vegetation surrounds them, and sluggishly flowing streams serve to drain most of them. The whole region being so heavily covered with glacial deposits there are few elevations and they are mostly portions of the several terminal moraines; the country rock rarely, if ever, appears in either natural or artificial sections. The beds of all the streams are full of glacial boulders and sands or gravels.

The Kankakee basin differs in no essential respects from those just described. It is worthy of note, however, that the course of this river, as indeed that of all within the drift area, has been largely determined by the moraines which cross the State in a series of irregular lines, most of which are north of the Wabash. The same general truth is apparent of the Maumee River, the course of which has certainly been determined by the glacial detritus over which it flows. But the general drainage level is so slight that there are sections, as those between Huntington and Fort Wayne, where, at seasons of the year when the streams are all at full flood, the waters indifferently flow to either the Atlantic or the Ohio drainage. This important fact will be again noted in the matter of distribution of the mollusks of the two regions.

The region drained by the Wabash and the White rivers is, in many respects, widely different from the region previously described. For many miles of its course the upper Wabash flows through canons cut into the country rock within its own life history; at Wabash and Peru the real nature of this corrasive work is well exhibited. But higher up the canon is deeper and the stream less wide; suddenly it rises high on the surface and flows along over glacial detritus, like the rivers farther to the north. That it flows, for some part of its course, in preglacial channels is true, but it is also true that it has abandoned those channels in other portions of its course. It results from this that its character changes at various points along its course; a fact of importance that should be borne in mind in discussing the distribution of the fresh-water mollusks found in its waters.

Both the basins of the White rivers present two features in common; they flow, at their beginning, over a surface covered with glacial matter and then suddenly pass beyond its limit of distribution and flow in channels through regions

the physiographic features of which were determined in preglacial times. In the upper portion of their courses, therefore, they present similar features to those of the upper Wabash, but in their lower valleys they are quite different though alike in most respects when compared with each other. The highest and roughest region of the State is drained by the White River and the small Wabash contributary basin, the Patoka. This region is the least well known conchologically.

The Whitewater basin is very like the upper Wabash and for the most part is entirely within the limit of glaciation, which reaches the Ohio in the vicinity of Lawrenceburg, in Dearborn County. The lower portion of the Whitewater is peculiarly sandy and does not seem to be suited to very great development of molluscan life.

The long and narrow basin of the Ohio is very rough and the country rock, chiefly limestone, everywhere appears in the bluffs and along the small tributary streams. In certain of the smaller streams of this basin Strepomatid shell life appears in great abundance, but the Unionid fauna is mainly confined to the Ohio itself and no species appear which are not to be found in that stream

From these facts it is evident that a wide diversity of environmental conditions is exhibited in the several basins as herein outlined. These differences find corresponding variables in the waters of the streams; in some they are quite soft, while in others the waters are very hard. Most of the small lakes in the northern portion of the State present waters that are very hard; in them the waters are often so highly charged with calcium carbonate that it is deposited thickly on the portions of the shells that project above the bottoms in which they are partly buried. In many of the streams the same facts are to be observed; this is especially noticeable in the upper Wabash, the shells from which are all more or less heavily coated with this substance. Collections from lower down, notably from Terre Haute to the mouth, are almost entirely devoid of this accretion.

It is important to note the molluscan facies of the various drainage areas and by a comparison of their faunas seek to correlate, if possible, the facts of distribution with the physiographic and geologic features. The physiographic features have already been noted; to facilitate comparisons of this nature lists of the mollusks have been collated, in every case based upon specimens actually collected at one or more localities in the several basins. While these lists are incomplete in that they do not represent the full richness of the several faunas they have proven instructive and may be useful in the general biologic study now undertaken by the Academy. These lists now follow.

SUMMARY OF GEOGRAPHIC DISTRIBUTION.

SPECIES.	Ohio Basin.	Whitewater Basin.	Patoka Basin.	East White Basin.	West White Basin.	Wabash Basin.	Maumee Basin.	St. Joseph Basin.	Kankakee Basin.	Lake Michigan Basin.
UNIVALVES.										
Amnicola cincinnatiensis Anth.	x									
Amnicola limosa Say	x	x	x	x	x	x	x	x	x	x
Amnicola porata Say	x	x	x	x	x	x	x	x	x	x
Ancylus tardus Say	x	x	x	x	x	x	x	x	x	x
Bulinus hypnorum Linnæus					x	x		x		x
Helisoma bicarinata Say		x			x		x	x	x	x
Helisoma campanulata Say						x	x	x	x	x
Helisoma trivolvis Say	x	x	x	x	x	x	x	x	x	x
Limnophysa caperata Mull					x	x			x	x
Limnophysa desidiosa Say	x	x	x	x	x	x	x	x	x	x
Limnophysa humilis Say	x	x	x	x	x	x	x	x	x	x
Limnophysa palustris Mull	x	x	x	x	x	x	x	x	x	x
Limnophysa reflexa Say	x	x	x	x	x	x	x	x	x	x
Menetus exacutus Say.				x	x	x			x	
Physa ancillaria						x				
Physa gyrina Say	x	x	x	x	x	x	x	x	x	x
Physa heterostropha Say	x	x	x	x	x	x	x	x	x	x
Valvata tricarinata Say								x		
Somatogyrus subglobosus Say.	x	x				x				
Pomatiopsis lapidaria Say	x				x	x				
Campeloma decisum Say						x	x	x		x
Campeloma integrum DeKay					x		x	x		
Campeloma ponderosum Say	x					x				
Campeloma rufum Hald				x	x	x	x	x		
Campeloma subsolidum Anth					x	x		x	x	
Lioplax subcarinata Say	x					x		x	x	
Vivipara contectoides Binney						x		x	x	
Vivipara intertexta Say						x		x		
Vivipara subpurpurea Say						x				
Anculosa prærosa Say	x									
Anculosa trilineata Say	x									
Anculosa carinata Brug	x									
Angitrema armigera Say						x				
Angitrema verrucosa Say	x					x				
Goniobasis bicolorata Anth	x									
Goniobasis cubicoides Anth						x				
Goniobasis depygis Say	x									
Goniobasis infantula Lea	x									
Goniobasis informis Lea.	x									
Goniobasis interlineata Anth		x								
Goniobasis intersita Hald	x									
Goniobasis livescens Menke						x	x	x		x
Goniobasis louisvillensis Lea	x									
Goniobasis semicarinata Say		x								
Goniobasis spartenburgensis Lea						x				
Goniobasis pulchella Anth	x	x	x	x	x	x	x	x	x	x
Lithasia obovata Say	x					x				
Mesochiza grovesnorii Lea.						x				
Pleurocera canaliculatum Say	x				x	x				
Pleurocera elevatum Say	x					x				
Pleurocera moniliferum Lea	x					x				
Pleurocera simplex Lea	x									
Pleurocera subulare Lea	x					x	x	x		x
Pleurocera troostii Lea						x				
Pleurocera undulatum Say	x					x				

SUMMARY OF GEOGRAPHIC DISTRIBUTION—Continued.

Species.	Ohio Basin.	Whitewater Basin.	Patoka Basin.	East White Basin.	West White Basin.	Wabash Basin.	Maumee Basin.	St. Joseph Basin.	Kankakee Basin.	Lake Michigan Basin.
BIVALVES.										
Pisidium abditum Hald	x				x	x	x	x	x	
Pisidium rotundatum Prime								x		
Pisidium virginicum Bourg	x							x		
Sphærium fabale Prime						x				
Sphærium rhomboideum Prime								x		
Sphærium solidulum Prime	x	x	x	x	x	x	x	x	x	x
Sphærium sphæricum Anth						x				
Sphærium stamineum Conrad	x									
Sphærium striatinum Lam	x	x	x	x	x	x	x	x	x	x
Sphærium sulcatum Lam	x					x		x		
Sphærium transversum Say	x	x	x	x	x	x	x	x	x	?
Anodonta decora Lea	x	x						x		
Anodonta edentula Say	x	x	x	x	x	x	x	x	x	x
Anodonta ferruginea Lea					x					
Anodonta ferussaciana Lea	x	x	x	x	x	x	x	x	x	x
Anodonta footiana Lea						x		x		
Anodonta grandis Say	x	x	x	x	x	x	x	x	x	?
Anodonta imbecillis Say	x	x			x	x				
Anodonta pavonia Lea				x		x				
Anodonta plana Lea	x	x	x	x						
Anodonta salmonia Lea	x				x	x		x		
Anodonta shæfferiana Lea					x					
Anodonta subcylindracea Lea						x	x	x	x	
Anodonta wardiana Lea	x			x	x					
Anodonta suborbiculata Say						x				
Anodonta undulata Say								x		
Margaritana calceola Lea	x	x	x	x	x	x	x	x	x	?
Margaritana complanata Bar	x	x			x	x				
Margaritana confragosa Say						x				
Margaritana dehiscens Say	x					x				
Margaritana hildrethiana Lea	x			x	x	x				
Margaritana marginata Say	x	x	x	x	x	x	x	x	x	?
Margaritana monodonta Say	x					x				
Margaritana rugosa Barnes	x	x	x	x	x	x	x	x	x	x
Unio abruptus Say	x					x				
Unio æsopus Green	x					x				
Unio alatus Say	x			x	x	x			x	
Unio anodontoides Lea	x					x				
Unio arctior Lea	x				x	x				
Unio asperrimus Lea	x			x	x	x			x	
Unio camptodon Say	x	x?				x				
Unio capax Green	x					x				
Unio cicatricosus Say	x					x				
Unio cincinnatiensis Lea	x									
Unio circulus Lea	x			x	x	x	x	x	x	
Unio clavus Lam	x	x	x	x	x	x	x	x	x	?
Unio coccineus Lea	x			x	x	x			x	
Unio cooperianus Lea	x					x				
Unio cornutus Barnes	x			x	x	x			x	
Unio crassidens Lam	x					x				
Unio cylindricus Say	x			x	x	x			x	
Unio distans Anth								x		
Unio donaciformis Lea	x			x	x	x				
Unio dorfeuillianus Lea	x									
Unio ebenus Lea	x					x				
Unio elegans Lea	x			x	x	x			x	
Unio ellipsis Lea	x	x	x	x	x	x	x	x	x	x
Unio fabalis Lea	x					x		x		
Unio foliatus Hild	x									

SUMMARY OF GEOGRAPHIC DISTRIBUTION—Continued.

SPECIES.	Ohio Basin.	Whitewater Basin.	Patoka Basin.	East White Basin.	West White Basin.	Wabash Basin.	Maumee Basin.	St. Joseph Basin.	Kankakee Basin.	Lake Michigan Basin.
Unio fragosus Conrad	x				x	x				
Unio gibbosus Barnes	x	x	x	x	x	x	x	x	x	x
Unio glans Lea	x			x	x	x	x			
Unio gracilis Barnes	x					x				
Unio graniferus Lea	x					x				
Unio iris Lea	x	x	x	x	x	x	x	x	x	
Unio irroratus Lea	x			x	x	x				
Unio lachrymosus Lea	x	x		x	x	x			x	
Unio laevissimus Lea	x					x				
Unio lens Lea	x			x	x	x				
Unio ligamentinus Lea	x	x	x	x	x	x	x	x	x	x
Unio luteolus Lam	x	x	x	x	x	x	x	x	x	x
Unio metanevrus Raf	x			x	x	x			x	
Unio multiradiatus Lea	x	x	x	x	x	x	x	x	x	x
Unio multiplicatus Lea	x	x		x	x	x	x			
Unio mytiloides Raf	x					x				
Unio nasutus Say								x		
Unio obliquus Lam	x					x				
Unio occidens Lea	x	x	x	x	x	x	x	x	x	x
Unio orbiculatus Hild	x					x				
Unio ovatus Say	x					x				
Unio parvus arnes	x	x	x	x	x	x	x		x	
Unio perplexus Lea	x			x	x	x				
Unio personatus Say						x				
Unio phaseolus Barnes	x			x	x	x	x		x	
Unio plenus Lea	x					x				
Unio plicatus LeSueur	x	x	x	x	x	x			x	
Unio pressus Lea	x	x	x	x	x	x	x	x	x	x
Unio pustulatus Lea	x				x	x				
Unio pustulosus Lea	x				x	x	x			
Unio pyramidatus Lea	x					x				
Unio rangianus Lea	x					x				
Unio rectus Lam	x	x	x	x	x	x	x	x	x	x
Unio retusus Lam	x		x	x	x	x	x			
Unio rubiginosus Lea	x	x	x	x	x	x	x	x	x	x
Unio sampsonii Lea						x				
Unio securis Lea	x				x	x				
Unio solidus Lea	x					x				
Unio spatulatus Lea	x			x	x	x			x	
Unio subovatus Lea	x				x	x			x	
Unio subrostratus Say	x				x	x	x			
Unio sulcatus Lea	x				x					
Unio tenuissimus Lea	x					x				
Unio trian ularis Barnes	x			x	x	x				
Unio trigonus L a	x					x				
Unio tuberculatus Barnes	x	x	x	x	x	x			x	
Unio undulatus Barnes	x	x	x	x	x	x			x	
Unio varicosus Lea	x									
Unio ventricosus Barnes							x	x	x	x
Unio verrucosus Barnes	x				x	x				
Unio zigzag Lea	x			x	x	x				
Totals	127	46	37	61	81	[illegible]	49	59	57	33

From this table it will be observed that the species of the following list are quite generally distributed throughout the State, representatives having been seen from nearly every basin. It will be noted at once that most of these forms are o

wide geographic distribution over the northern United States, a fact which goes a long way, first, in establishing their high antiquity as species, and second, the fact that they have successfully adapted themselves to conditions which are widely variant. Many of them occur far to the southward, beyond the limits of glaciation, extending even to the middle portions of Alabama, some of them under other names than those which we are accustomed to apply to them here. Differences of a trivial character, the result of environment, appear to have been seized upon by the species makers and the older naturalists whose ambitions alike seemed to have been to write "*nobis*" after a specific name.

REGISTER OF GENERALLY DISTRIBUTED SPECIES.

Unio clavus.	*Unio ellipsis.*
* *Unio iris.*	*Unio pressus.*
Unio luteolus.	*Unio gibbosus.*
Unio ligamentinus.	*Unio rectus.*
Unio multiradiatus.	*Unio occidens.*
Unio rubiginosus.	*Margaritana calceola.*
* *Margaritana marginata.*	*Margaritana rugosa.*
Anodonta ferussaciana.	*Anodonta edentula.*
* *Anodonta grandis.*	*Sphaerium solidulum.*
Sphaerium striatinum.	* *Sphaerium transversum.*
Amnicola porata.	*Amnicola limosa.*
Limnophysa palustris.	*Limnophysa reflexa.*
Limnophysa desidiosa.	*Helisoma trivolvis.*
Physa heterostropha.	*Physa gyrina.*
Goniobasis pulchella.	

Summarizing this group of names, there are nine genera and twenty-nine species; of these four genera and twenty species are bivalves; the rest are univalves. There have been found up to this time, and thus certainly known to belong to the Indiana fauna, a total of one hundred and sixty-five species of fresh water shells. Nearly one-sixth, therefore, of our species are to be found all over the State; this proportion will certainly be increased on thorough exploration. Geographic series, which have been studied, of these widely distributed forms show some interesting facts in the line of variation, facts which are, most certainly, to be correlated with peculiarities of environment. This is especially true of those forms which are indifferently found in lakes, ponds or flowing streams, such as

*These forms have been found in all but one basin in Indiana, with every probability that each occurs therein and will be found on full exploration.

Margaritana rugosa and *Unio luteolus*. No two series, from the different areas, present exactly the same facies. So marked is this, in some cases, that the lake forms can always be separated from those which were obtained in streams. This general study is reserved for more abundant data and final discussion on another occasion.

A further study of the geographic tables will demonstrate that the richest shell faunas occur in the Wabash and the Ohio drainages, these two areas furnishing nearly the same species in common, though many of each are not generally distributed over the State. Of the shells which are both common and yet limited in distribution *Unio ebenus*, *Unio irroratus* and *Unio æsopus* among the bivalves, and *Campeloma ponderosum* and *Pleurocera canaliculatum* among the univalves will serve as types. The differences between the two basins may be noted from the following lists:

OHIO BASIN.	WABASH BASIN.
Unio camelus.	*Unio personatus.*
Unio varicosus.	UNIO SAMPSONII.
UNIO CINCINNATIENSIS.	*Anodonta suborbiculata.*
Unio foliatus.	*Margaritana confragosa.*
Unio dorfeuillianus.	*Sphaericum sphaericum.*
Sphaerium stamineum.	**Sphaerium fabale.*
Anculosa praerosa.	*Goniobasis spartenburghensis.*
Anculosa trilineata.	*Goniobasis livescens.*
Anculosa carinata.	*Goniobasis cubicoides.*
Goniobasis bicolorata.	*Angitrema armigera.*
Goniobasis depygis.	MESESCHIZA GROVESNORII.
GONIOBASIS INFANTULA.	*Pleurocera troostii.*
Goniobasis informis.	*Vivipara subpurpurea.*
Goniobasis intersita.	*Vivipara contectoides.*
GONIOBASIS LOUISVILLENSIS.	*Vivipara intertexta.*
Pleurocera simplex.	*Menetus exacutus.*
Amnicola cincinnatiensis.	*Campeloma decisum.*
	Campeloma rufum.
	Campeloma subsolidum.
	Limnophysa caperata.
	Planorbella campanulata.

*Not seen; admitted to the list on the authority of Temple Prime, vide "Catalogue of the Species of Corbiculadæ," p. 10, 1863.

Here are totals of eleven species found in the Ohio basin against fifteen which are found in the Wabash basin. The proportion would be substantially the same if the synonymous forms included, printed in small capitals, were excluded from the list. None of the members of the genus *Vivipara* appear in the Ohio basin, while but two *Uniones* are found in the Wabash basin that are not found in that of the Ohio. No limnæids appear to be characteristic of the Ohio basin, while three such are found in the Wabash. Yet it is to be constantly borne in mind that further collections may invalidate this comparison by the discovery of other common forms, or that some of these forms may yet be ascertained to be common to the two faunas.

Turning again to the northern portion of the State, the most interesting fact presented is the existence of a number of Ohio drainage forms in the Maumee River, a stream of the Atlantic drainage. Opportunity was afforded the past spring to make a small collection in the Maumee and the St. Mary's Rivers at Fort Wayne, well within the Maumee Basin. While the collection was by no means exhaustive, it developed some very interesting facts which possess more than a passing significance.

Among the Ohio River forms found were the following:

Unio rubiginosus,	*Unio clavus,*
Unio glans,	*Unio gibbosus,*
Unio luteolus,	*Unio parvus,*
Unio retusus,	*Margaritana calceola,*
Margaritana complanata,	*Goniobasis pulchella,*
Anodonta edentula,	*Unio pressus.*

These species are accredited to the Western fauna, and most of them are not hitherto recorded as belonging to the Atlantic fauna. Two of these were so recorded by the writer as long ago as 1877, in the Erie Canal, in the Mohawk drainage, at Mohawk, N. Y., and record made of the fact in the "American Naturalist," Vol. XII, pp. 472, 473. Other records have since appeared. *Unio luteolus* is often quoted in faunal lists used for exchange purposes by Eastern collectors, but in every case where specimens have been secured, thus far, they have proven to be the male forms of the totally distinct *Unio cariosus*, a form not yet found in Western waters. *Anodonta edentula* may be, and probably is, a geographic variety of the Eastern *Anodonta undulata*, but the Maumee forms are Western in facies. It is therefore proper to regard it here as a Western shell in the drainage of an Atlantic stream. So far as the specimens go which are in my possession, they do not present very marked differences from the same shells found a few miles to the west in waters tributary to the Wabash. The environmental factors are precisely

the same in both areas, and there should be no marked differences. There are none. But mingling with the Western fauna of the Upper Wabash were found large numbers of the Eastern strepomatid shell, *Goniobasis livescens*, a form which is abundant from New York throughout Northern Ohio and along the Great Lakes. Near Huntington, on the Wabash, this shell was the most abundant strepomatid found. The same facts were true of the St. Mary's and the Maumee, though the greatest numbers were found in the former stream, clinging to the rocks along the banks, in the heart of the city of Fort Wayne. Associated with them were large numbers of *Pleurocera subulare*, a form abundant in the East, but also of wide Western distribution, and an undetermined pleuroceroid mollusk of Western affinities. It closely resembles *Pleurocera lewisii*, but of this determination I am yet uncertain.

It is important to note, in this connection, that the headwaters of the Aboite River, or its east fork, approach to within three miles of the St. Mary's at Fort Wayne, and that the divide at that locality is hardly perceptible. Moreover, the Wabash & Erie Canal has long established water communication between the two basins—probably long enough to establish interchange of faunas, especially in the case of the univalves, which are far more migratory in their habits than the Unionidæ. This is the case in the Erie Canal in New York, by means of which the advent of the Western fauna into Eastern waters may be almost chronologically traced. To offset this possible explanation is the fact that the species seem to be well established, and occur, many of them, in great numbers in the Maumee Basin. But, whatever the explanation, the species appear in the two basins, and in them both there is a commingling of the two faunas, with but few Western representatives of the Eastern fauna. The Eastern representatives in the Western fauna greatly outnumber, both in species and individuals, the Eastern fauna in the Western Basin.

The suggestion of the relation of this distribution to glaciation and its physiographic results has before occurred to the writer, though in another connection. As long ago as 1886, in discussing certain anomalies in the distribution of Ohio River forms of *Unionidæ* in the State of Kansas, attention was directed to this problem in the following language: "Considerable data have accumulated in the hands of the writer which seem to imply the necessity of correlating this peculiar distribution with certain facts in glacial geology, but those data will not warrant the statement that such correlation exists. Attention is directed to this problem in the hope that other observers may use their opportunities and supply all the in-

formation possible."* A recent writer proposes** the same explanation for the distribution of the two faunas in this region and, from the facts we have herein adduced, the locality offers most excellent opportunities for a careful study of the problem. Yet, the fact of the artificial connection of these two areas must constantly be borne in mind. A second region where the heads of the drainage areas are practically coincident occurs in Kosciusko County, where the several small lakes and general low-lying region are all drained by streams which flow either into the Tippecanoe or the Turkey rivers, the first of which is tributary to the Wabash, the second to the St. Joseph's, of Michigan. A low moraine separates the two basins. This is the location of the Biological Station of the State University which will, presumably, interest itself in this question.

An investigation of the fauna of the Upper Wabash that would be complete might disclose others of the eastern species in its waters. Strong corroborative evidence might be secured through the ichthyic fauna of the two rivers, the Wabash and the Maumee, for, if the suggestions of this paper are tenable, some degree of correspondence should be disclosed by a study of the fishes. This correspondence, if it exists, will aid in understanding the method of distribution of the *Unionidæ* which is so largely effected through the medium of fishes.

Vide, Call, "Fifth Contribution to a Knowledge of the Fresh-Water Mollusca of Kansas," Bull. Washburn College Laboratory of Natural History, vol. i. No. 6, pp. 178, 179, 1886.

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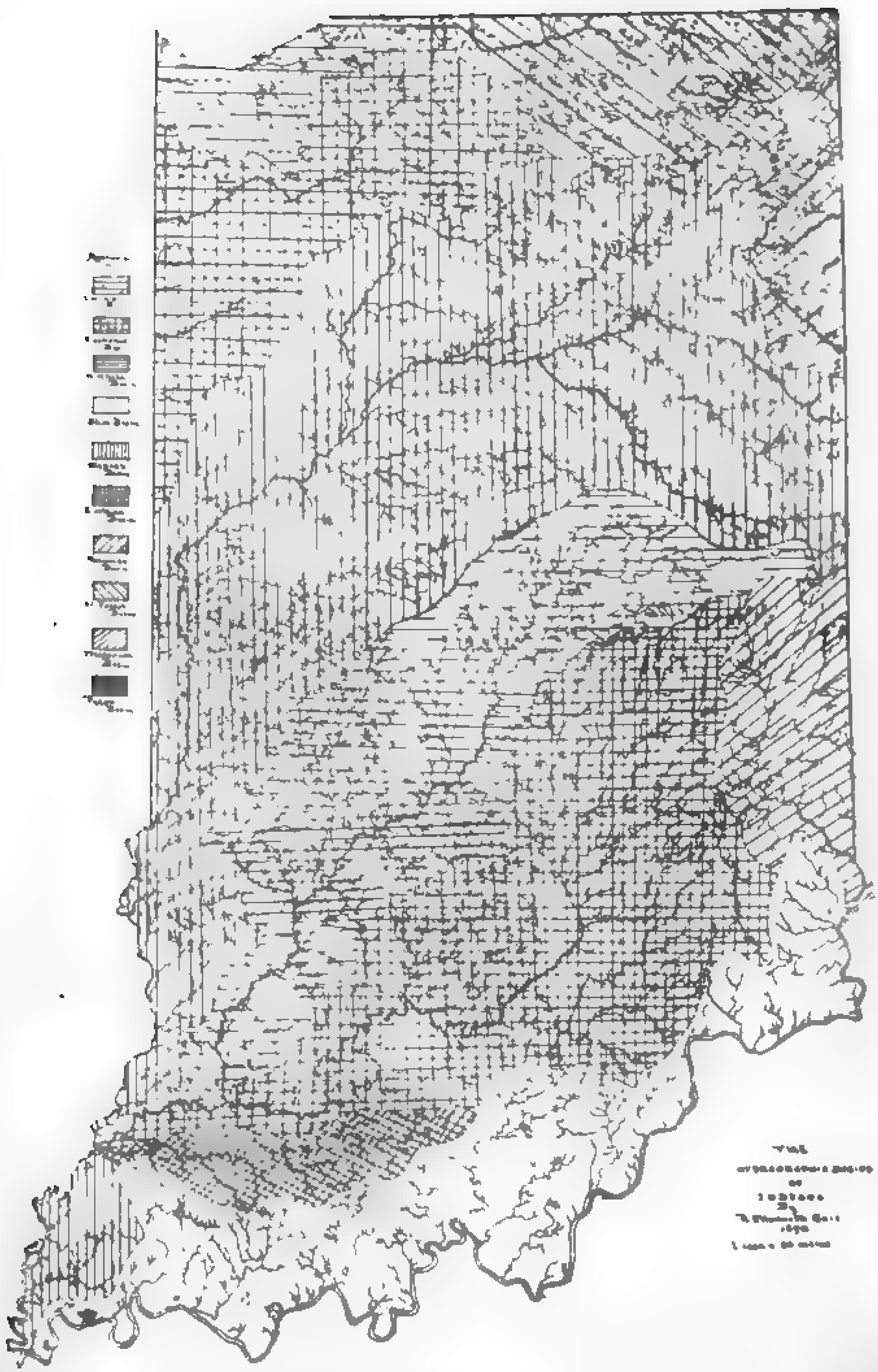

THE AMERICAN INDIAN, HIS RELIGION. BY GEORGE L. CURTIS.

NOTES ON THE ORIGIN OF THE EPIPHYSIS CEREBRI IN AMIA. BY B. M. DAVIS.

[ABSTRACT.]

The presence of the *epiphysis* in all the vertebrates from the Cyclostomes up has made it an object of study among comparative anatomists for a long time. Its structure and development has been described for all the groups except the Ganoids.

I have had occasion lately (together with Dr. Eyclescheimer of Chicago University) to examine the early development of this structure in Amia calva, and this is merely a preliminary note to a more detailed and complete account, which will be published later.

It has been described (*e. g.*, Hertwig's Embryology) as always arising in exactly the same way, *i. e.*, as a forward evagination of the roof of the thalamencephalon. As a matter of fact, however, the opposite is true in several forms. (Petromyzon, Acipenser, Amia, Chick.)

Its first appearance in Amia is in a larva still uncoiled from the yolk. It is noteworthy that it does not appear this early in all individuals. In some cases it does not develop until the larva has uncoiled from the yolk and has attained a length of four or five millimetres.

It is at first a simple fold in the brain-roof directed backward. There are no histological features which would distinguish it from the adjacent parts of the brain.

The stages immediately succeeding this show a gradual change in structure. The upper part of the fold is differentiated into the *epiphysis*. It is a glove-finger-like structure, with its cavity bounded above by two rows of cells and below by several.

The distal end for some time remains much the same in structure, but the dorsal wall of the proximal end becomes thickened. This thickened portion extends forward and becomes the so-called "anterior vesicle." From the time of origin it would seem that "secondary vesicle" would be a better designation.

The two vesicles are attached to the brain-roof by a stalk and have a common opening into the thalamencoele.

Later the anterior or secondary vesicle shifts to the left, and from the ten-millimetre stage on is found to the left of the primary vesicle.

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THE SNOWBIRD AT NIGHT. BY W. P. SHANNON.

ON THE OCCURRENCE OF SEVERAL FAMILIES OF AQUATIC ANIMALCULÆ IN NEW STATIONS. BY ELWOOD PLEAS.

On February 25, 1896, while searching a small lichen for diatomes that might have found a possible lodgment, it was a matter of much surprise to find a large and active *Rotifer vulgaris* measuring its length across the microscopic field. Farther examination of this lichen, as well as others from the same and neighboring trees, logs, stumps, board and rail fences, disclosed the fact that the *Rotifera* (in several genera and species), *Anguillula fluviatilis*, *Macribiotus americanus*, *Paramœcia*, and many more minute flagellate *Monads* (some or all of them) might be expected in every lichen, in short, compact, growing mosses, and in fact wherever a cryptogam can be found.

The temperature was below freezing when the first lichens were collected, and had been 15° below zero a few days earlier, but upon soaking the lichens for a minute or two in about as much water as they would absorb, and squeezing into a small dish and transferring two or three drops (dregs and all) with the dipping tube to a slip or cell, it was generally found that some or all of these strangely domiciled animals had already resumed the functions and activities of life.

A few of these microscopic animals had become quite familiar as denizens of almost every ditch and pool in the land, but the astonishment was scarce greater at finding *such* creatures in *such* a habitat than at the great variety and vast numbers of them on exhibition.

On March 22 a lichen about 1 x 1½ inches, pared from the upper edge of a fence board, yielded 203 rotifers, besides other living forms.

Examination was not resumed until December 4, when a lichen about 1½ x 1½ inches, yielded 69 rotifers, 18 water eels, 7 water bears, several Paramœcium and many minute flagelate protozoa.

On December 13, a fragment of lichen 1¼x1¼ inches square slipped from the bark of a May cherry, yielded 828 "wheel bearers," 10 "water eels," 25 "water bear," and greater numbers of minute infusoreæ; while on the same day, from a minute greenish yellow lichen, estimated at ⅛ inch in diameter, there were taken 65 rotifers, 4 eels, 1 bear and 4 mites.

So universal seems to be the distribution of some of these forms that the difficulty is to find a spot where lodgment is possible not already occupied.

On December 19, from the calyx of an apple that had been in a dry cellar for a month 2 rotifers and 6 eels and other things were obtained, and 3 apples yielded 32 of these forms, fragments of insects and the wreckage of various filamentous fungi, and innumerable unknown spores and bacteria.

The writer of this paper has neither the fine microscopic appliances nor works of reference necessary for a close study and determination of the most minute forms observed, and the names of a few in the list which follow are given provisionally. We are, however, indebted to the distinguished microscopist and widely known writer and author of several splendid books on microscopic subjects, Dr. Alfred C. Stokes, of Trenton, New Jersey, for having examined material sent and identified a dozen or more of the species in the list, which is as follows:

INFUSORIA.

Amphileptus, sp. ?.
Heteromita, sp. ?.
Tellina, sp. ?.
Vorticella, sp. ?.
Paramaecia, sp. ?.
Chilodon, sp. ?.
Free swimming *Monads*, several sp. ?.

RHIZOPODS.

Euglypha Cilliata.
Euglypha alvealata. ?.
Arcella vulgaris.
Amœba verrucosa.
Assulina seminulum.
Difflugia pyriformis.
Difflugia corana ?.

Eels, Mites, Etc.

Anguillula fluviatillis.

Alacrobioties americanus.

Water Mite, sp. ?.

Mite, sp. ?; probably terrestrial.

Entomostraca, resembling *Dioptomus.*

Rotifera.

Rotifer vulgaris,

Rotifer, 2 sp. ?.

Philodina aculeata.

Rotifer, eggs, sp. ?.

Algæ.

Nostic lichenoides, ?.

Pratococcus viridis.

Spirogyra, sp. ?.

Oscillaria, sp. ?.

Diatomes, species, ?.

Examples of lichens rich in the aquatic organisms above listed were sent to half a dozen prominent microscopists with the request that they report the things found in them, and whether the finding of such creatures in such habitats was new; and if not they were requested to cite some article or work of reference giving information upon the matter.

All expressed surprise at the find and failed to cite any work of reference, save a distinguished lady of Pennsylvania, who referred to Dr. Joseph Leidy (XII vol. Hayden's Geol. Rep., 1870), where, in speaking of Rhizopods, he says, substantially: "While essentially aquatic," they occur wherever there is moisture, commencing with one's own doorstep and extending to ocean's depth, and even upon the bark of growing trees, etc., etc.

The theory generally advanced to account for the sudden appearance of countless numbers of *Bacteria, Infusoria, Rhizopoda*, etc., in cisterns, watering troughs, transient pools and puddles of water, is that they or their eggs or germs have been gathered up from dried-up ponds and ditches by the summer winds and carried for long distances and deposited on walls and roofs, etc., from whence they are washed by copious rains and afterward germinated, or are developed or revived.

While this may be true in part as to some of the almost structureless Protozoa, it would seem scarcely sufficient to account for the appearance of the more highly organized *Rotifers, Anguillula* and mites, in the driest of dry lichens, in every stage of development from egg to the full-grown animal, and that in the

dead of winter. One of the correspondents reporting on material sent for examination, twice reported Rotifer eggs, and the second time as being furnished with hooked spines, and the young rotifer alive within the egg and its mastax in operation; while on December 5th the writer witnessed a Macrobiotis *ovipositing* in its peculiar style, which consists of depositing a dozen or more rather large eggs in the posterior portion of its skin and frantically scrambling out at the front end, and leaving the sack for the use of its young.

The first animals found were of various sizes, last February, and must have occupied the position in which they were discovered for several months at least; and to test their capacity for withstanding great and sudden vicissitudes of weather, both those in the lichen and those soaked out have been dried within six inches of a gas stove, running day and night for two weeks, and a portion of the Rotifers, Eels, Bear and Infusoria resumed life after soaking five to ten minutes. The thermometer indicated that they were withstanding the temperature and desiccation of 75° to 110°. Some of those washed out and put to dry (in a teaspoonful of water) were resoaked and redried four or five times at intervals of twenty-four hours.

Others were subjected to zero temperature for 2½ hours, and after being thawed over a gas jet a few Rotifers and Eels were resurrected in five to 10 minutes, but no Infusoria appeared to have withstood the ordeal.

A very surprising feature of the survey taken is, that of the thousands of minute living forms forced to pass in review, certainly not one in a hundred were of such as are commonly regarded as *terrestrial*. Insects were mostly represented by fragments.

In view of the facts cited the problem, from whence came these myriads? may not be solved, but it does seem clear that the "*germ*-and-egg" transportation theory of their distribution is insufficient.

Notes on the Biological Survey of Milan Pond. By A. J. Bigney.

Milan Pond is situated in the eastern part of Ripley County, one-fourth mile east of the village of Milan. The pond is an artificial one, having been constructed by the old O. & M. Railroad in 1854 as a watering station. It is nearly one-half mile long and one-fourth mile wide. Its greatest depth is twelve feet. It receives water from four small streams, but is drained at a certain height, so that it keeps at the same stage most of the time, except in dry seasons. In the summer of 1895 it would have gone dry had not the railroad company kept it supplied with transported water. This is the only time it has been very low.

However, there was sufficient water in it during that season to prevent much interference with the life forms. Since then the life has been just as abundant.

Since the organization of the Biological Survey of Indiana I have thought it would be profitable to make a study of the plants and animals of this pond in order to discover the forms existing and to note any change in the organisms during a number of years and to record any facts of interest in biological lines.

This paper makes no pretensions of being exhaustive, but is merely intended to be preliminary, for I have not had an opportunity to make a thorough study of the forms of life.

I. *Botany.*—On the banks of the pond are found the ordinary hard-wood trees of Indiana and much shrubbery, such as the elder, willow, hazel and gum. Many of the smaller Phanerogams abound on the margin, but very few occur in the shallow waters. The pond is very rich in algæ, such as spirogyra, zygnema, vaucheria, oscillaria, euglena, diatoms, desmids and kindred forms. No classified list has yet been made.

II. *Animals.*—Among the vertebrates are to be found several kinds of snakes, wild ducks, several species of snipes, frogs in great abundance, sun-fish, cat-fish and carp. The insects have many representatives. The crustacea are really the most numerous. Crayfish, water-fleas, ostracods, copepods, isopods, and amphipods and rotifers are almost without number. Several species of worms occur, and among the mollusks physa, limnæus and planorbis are quite plentiful. It is the best place for hydra, both brown and green, that I have ever found anywhere. In the dry seasons the pond scums are almost filled with them. In even a small handful of the algæ I have found more than a hundred. Among the porifera is the fresh-water sponge, spongilla. This is the only place that it has ever been found in this section of the State. The pond is also rich in protozoans. All the forms will be classified and described during the coming year. The pond is very valuable for laboratory purposes.

SUICIDE OF A CROW. BY STANLEY COULTER.

The paper reported the finding of the body of a crow under the following circumstances: The head of the crow had been passed between the trunk and a strip of the bark of the ordinary shell-bark hickory. Its withdrawal was prevented by the projections of the occipital bone. The protruded tongue, the bulging eyes, and the position of the body showed that death had occurred by strangulation. The location of the tree in an unfrequented portion of the woods, and the fact that the crow was suspended much above the reach of any one furnished sufficient evidence that it was responsible for its own death.

THE RANDOLPH MASTODON. BY PROF. JOS. MOORE.

The genus Mastodon, belonging to the elephant family, began as far back in time as the miocene, or middle tertiary, and continued into the earlier centuries of the present epoch. First and last there have been as many as twenty known species, distributed about as follows: Europe nine, Asia five, N. America four, S. America two. Remains have been found in Australia which have been claimed for Mastodon, but naturalists are waiting for the claim to be better substantiated.

The species known to N. America are, *M. Americanus* (same as *M. giganteus* or *M. ohioticus*), *M. obscurus*, *M. productus* and *M. murificus*. The only species found in Indiana or adjoining states, so far as I have learned, is *M. Americanus*. That this majestic creature once trod our wilds in prehistoric times, roaming in herds from Canada to the Gulf, feeding on the prairies, in the forest jungles and on the banks of lakes and streams, often getting helplessly and fatally mired in our bogs—that it did all this and more seems to be quite satisfactorily evident.

They must have been crowded slowly southward before the great ice sheet, and afterwards followed the retreat of the same northward that they might possess the land in company with the Mammoth and other great beasts during the champlain and terrace epochs and into the beginning of the present.

It is a common thing to find Mastodon remains. Hardly a week passes but that some paper near or far reports a find. Often it is a false report, but probably oftener it has some foundation in fact, even if the discovery be but a grinder or part of a tusk.

People say they never lived in herds here for thousands of years, or with all the digging for wells, sewers, cellars, railroads and hundreds of other things, we would be finding remains every few hours. There were millions of horses in Indiana previous to, say, 1860. Now send out a company of explorers to find skeletons of horses that died previous to said year and see how many they will bring in. But it is far from common to find the skeleton of a Mastodon that is approximately complete, and rarer still to find such an one which, on drying, does not crumble to bits.

Near twenty years since a farmer struck some very large bones and a tusk two or three miles from New Paris, Ohio. A number of the bones were well preserved. A tusk was taken out, entire, which measured near eleven feet in length and ten inches in diameter at base. Such a tusk would seem to indicate a powerful male of full age. On drying, for want of proper treatment, this majestic specimen went to crumbs and splinters, except three and a half feet of the outer end. The other remains consisted of a pair of grinders, half a dozen vertebræ, more than a dozen

ribs, stumps of the scapulæ, one femur, one humerus, the lower segments of the hind legs, the main part of the sternum and a few feet bones. After the original purchaser had tried the show business for a time, said remains were secured for Earlham College.

Some eight years later a Mr. Bookout, near Losantville, Randolph County, while ditching to drain a small bog abounding in peat, struck the major part of an entire skeleton, which almost exactly matched, for size, the New Paris remnant. While the head was of extraordinary size, the tusks were but moderate. The pelvis was six feet, two inches across and ample in every direction. This was most likely a female. In prying at the larger parts, the head and pelvis, to remove them from the mud they parted, each into a number of pieces. These, on drying for years, would of course crumble at the broken edges. These massive fragments of head and pelvis were sent to Ward & Co., of Rochester, New York, who arranged them in original position, and so welded them by filling in the gaps that only an expert would suspect they had ever been in fragments.

The Randolph remnant, in addition to the head and pelvis, gave us about half the vertebræ, both scapulæ, radius and ulna, both right and left, one good femur, the right, a majority of the ribs, and near a bushel of feet bones. The Randolph remnant would have been secured when first taken up but for the price. By waiting more than eight years it shrank to less than a quarter the original standard.

The composite skeleton as it now stands was mounted by the curator of the museum, assisted by a very efficient student. It is nearly all bone. Both remnants, however, furnished but one humerus, the right. The lower jaw is perfect, with all the grinders. The tusks are paper but are moulded exactly after originals. A tusk of the Randolph find lies on the platform, but was too heavy in its brittle condition to mount. Of the vertebræ, including those of the neck, body and the larger joints of the tail, thirty-six are bone. Of the thirty-eight ribs all are bone but three. The hind legs are all bone except the fibula on the right side. The sternum is bone.

From the pedestal to the top of the highest spine is eleven feet, less half an inch. From pedestal to crown of head is eleven feet two inches. From pedestal to summit of pelvis, nine feet. From sole of foot to top of scapula, nine feet, seven inches. From forward curve of tusks to backward curve of tail, twenty feet, two inches. It ranks among the largest of known mastodons. Such a creature when alive could scarcely have weighed less than ten tons.

The Increasing Abundance of the Opossum (Didelphis virginiana Shaw) in Northern Indiana. By Albert B. Ulrey.

[Abstract.]

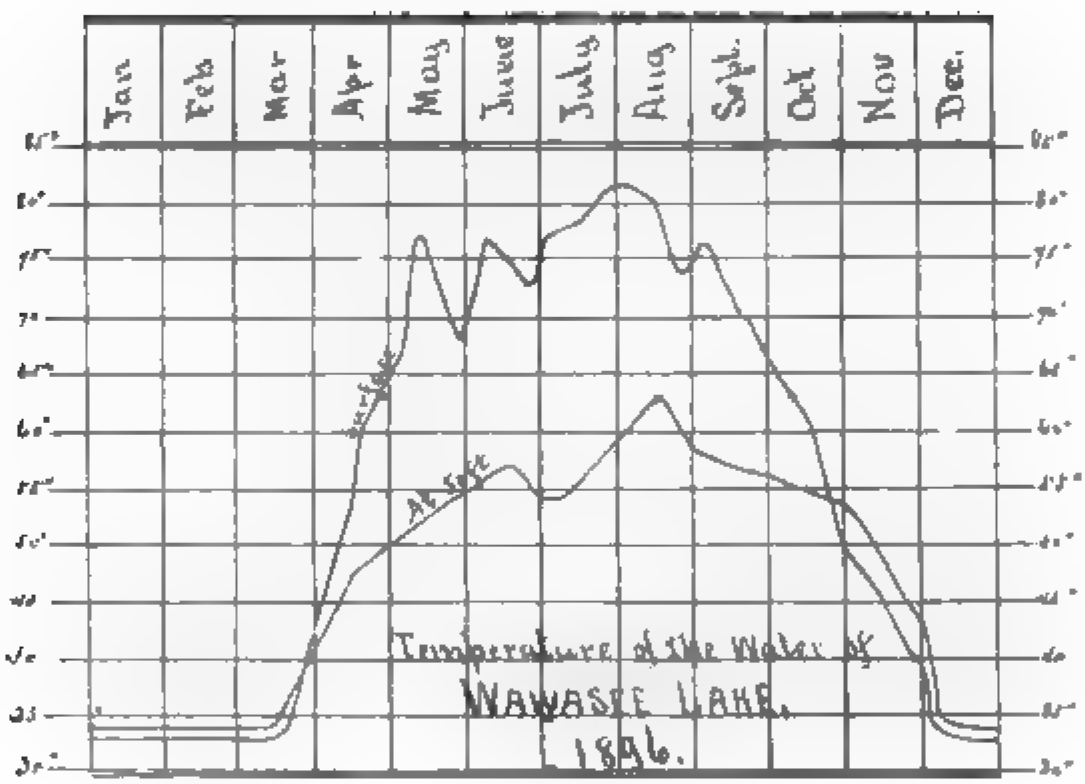
During the past year my attention has been called to the fact that an unusual number of specimens of the Common Opossum has been taken. On inquiry I found this was true not only in the immediate vicinity, but reports from other places in northern Indiana indicated a similar increase in abundance. The past few years show a somewhat progressive advance in numbers.

Temperature of Lake Wawasee. By J. P. Dolan.

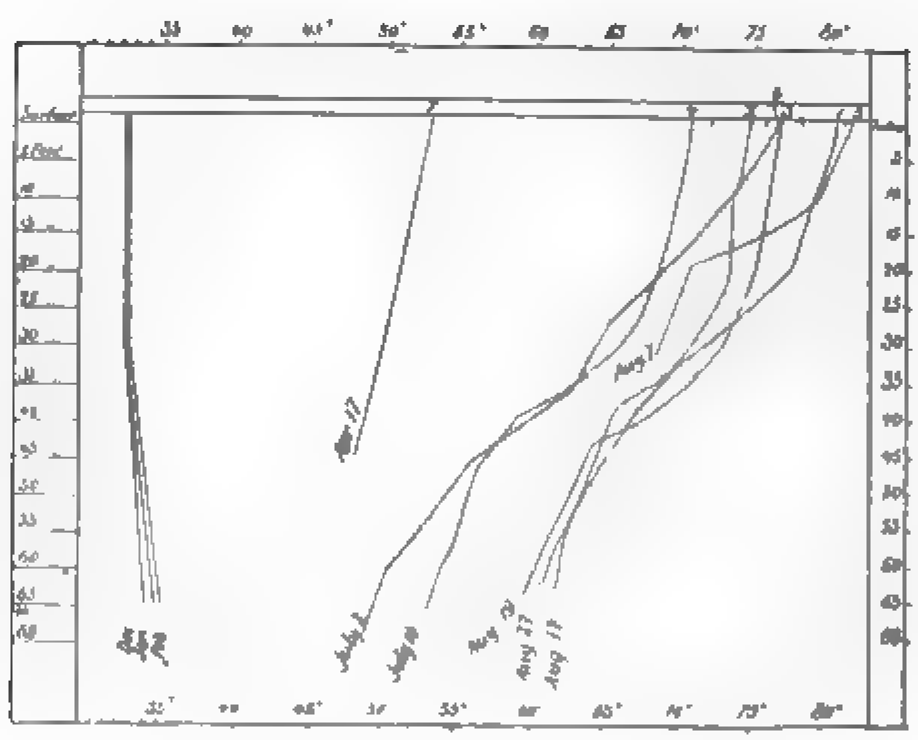
One of the problems presented in the study of the temperature was, "Does a period of stagnation obtain for any considerable period, especially during the summer months?"

It will be seen by a perusal of the tables and charts that during the winter months, when the lake is covered with ice, that there is only a slight difference between the surface and bottom temperatures, but that during the summer months there is much difference. What was only conjectured after a few months' observation last year is now conclusively shown, namely, that no condition of stagnation obtains during the summer and autumn months.

It will also be seen that, notwithstanding Lake Syracuse is forty feet shallower than Wawasee, the temperature of the former is from one to two degrees higher, both top and bottom, than the latter during the summer months.



TEMPERATURES OF LAKE WAWASEE.



Nos. 1, 2, 3, 4. N. E. Bio. Laboratory.
5. Mouth of Johnson Bay.
6. Jarrett's Bay.
7, 8, 9, 10. West of Blk. Stump Point.

TEMPERATURES OF LAKE WAWASEE.

	West of Black Stump Point.					N. E. of Bio. Laboratory.					Johnson's Bay.		Jarrett's Bay.		Crows Bay.	Off Cedar Point	Garrs Lake
											North End.	Mouth					
	Jan. 18. A. M.	Feb. 2. A. M.	Feb. 14. A. M.	Apr. 17. P. M.	June 25. P. M.	July 1. A. M.	July 10.	Aug. 17. P. M.	Aug. 19.	Aug. 27. A. M.	July 14. P. M.	Aug. 7. A. M.	July 2.	Aug. 21. A. M.	Aug. 21.	July 20.	July 29.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Air	35	......	......	......	86	......	......	73	......	......	91½	88	......	77	82	71½	96
Surface	33	34	33	53	73	76½	71½	80	77	74	78½	81½	77	77	78	71½	81
5 feet deep	33	34	33	......	......	......	71	......	......	......	78	......	......	......	......	......	78
10 feet deep	33	34	33	52	72	......	70½	79	76½	73	77	79½	73½	75½	77	71	72
15 feet deep	33¼	34	33	......	71	......	69¾	......	......	......	70½	76	......	......	76	......	62
18 feet deep	......	......	......	......	......	......	......	......	......	......	*69½	......	......	......	......	......	......
20 feet deep	34	34	......	......	70	......	69	78	76	73	......	72	70½	75	76	69½	52
25 feet deep	34	34½	......	50	......	66¾	67	......	......	......	......	......	......	......	75	......	51½
30 feet deep	34	34¼	......	......	......	......	65	72	71	......	......	70	65½	72	73	66	50
35 feet deep	34	34¼	......	49	69	......	60½	......	......	......	......	*69½	......	70	70	65	49½
40 feet deep	34	35	......	......	......	......	56½	64	64	66	......	......	62	68	67	*64¾	49
45 feet deep	34	35	33¾	*48	......	......	55	......	......	......	......	......	56	67	66	......	*48½
50 feet deep	34	35	......	......	*68	51½	54½	63	62¾	......	......	......	53½	......	*66	......	......
55 feet deep	34	35	......	......	......	......	54	61½	......	......	......	......	50½	59	......	......	......
60 feet deep	34	35	34	......	......	......	53	61	61¼	62½	......	......	50	57½	......	......	......
65 feet deep	34	35½	34	......	......	53½	......	61	......	61	......	......	49½	57	......	......	......
66 feet deep	......	......	......	......	......	......	52¾	......	59¾	......	......	......	......	......	......	......	......
68 feet deep	......	......	......	......	......	......	......	......	......	......	......	......	49	57	......	......	......

*Bottom.

TEMPERATURES OE SYRACUSE LAKE.

January	10	17	27	28	29	30	31
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg	Deg.
Surface	33½	34	35	35	35	35	H'v'y.
Bottom, 25 feet	35	36	37	37	37	37	Fog.

February	4	6	7	11	22	29
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Surface	35	34	34	34	33	35
Bottom, 25 feet	36½	36	36	36	36	37
15 feet	......	......	......	......	......	37

March	2	9	10	12	16	22	23	25	31
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Surface	35	35	34½	......	35	......	36	37	46
Bottom	36½	37	37½	......	37	......	38	39	45
15 feet	......	......	36	......	......	36	38	41	......

April	1	2	11	17	18
	Deg.	Deg.	Deg.	Deg.	Deg.
Surface	43	40	46	60	60
Bottom, 25 feet	43	......	44	54	55
15 feet	......	......	52	......	......

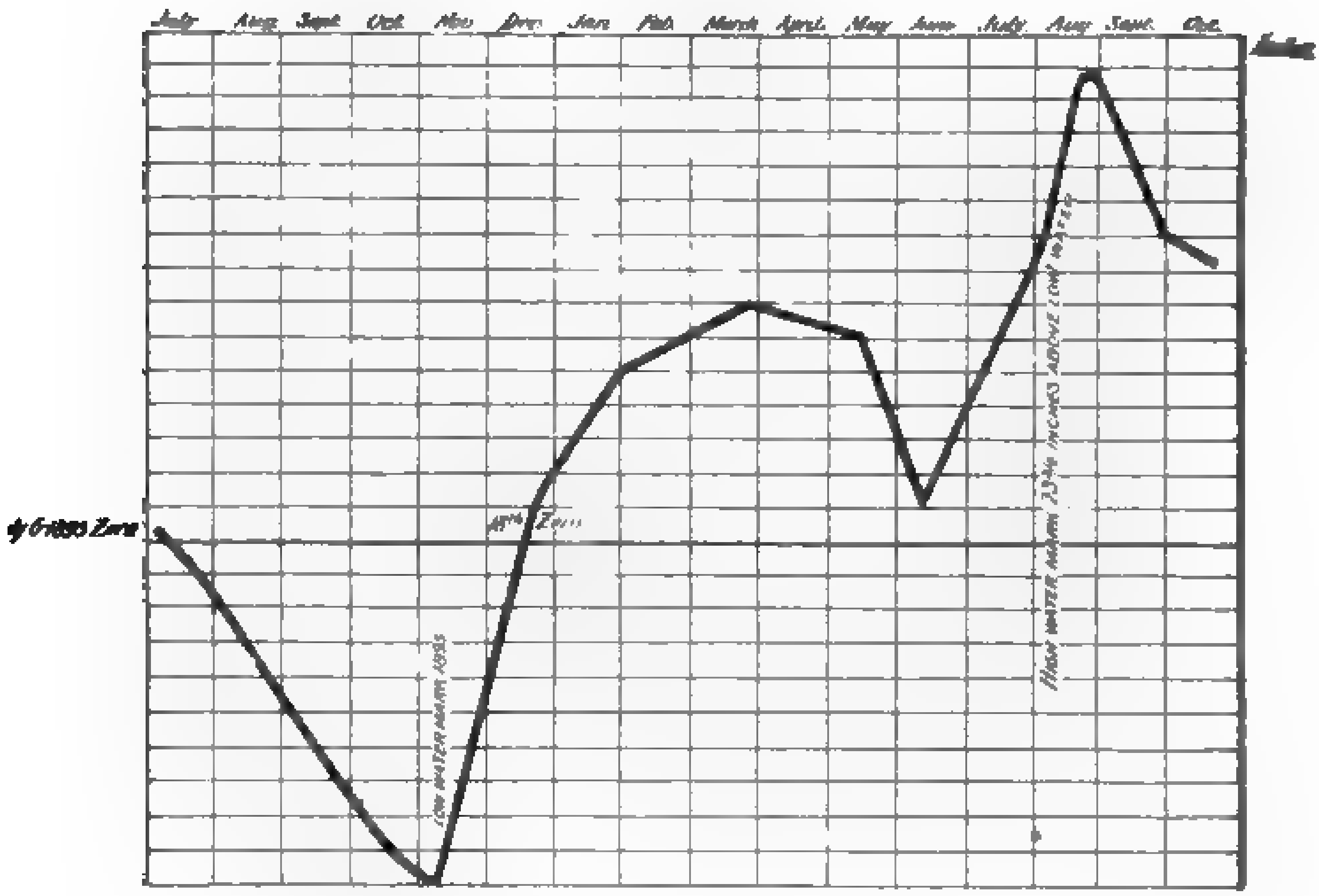
May	2	4	6	11	12	13	16	21	25	28
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg	Deg.	Deg.	Deg.	Deg.
Surface	66	67	70	75	77	76	69	68	70	68
Bottom, 25 feet	63	65	64	62	62½	63	63	66	65	66

June	2	4	7	13	19
	Deg.	Deg.	Deg.	Deg.	Deg.
Surface	72	74	77	72	76
Bottom, 25 feet	67	66	67	67	......

Ice gone from lake.

Temperatures were taken at 4:30 P. M. uniformly.

RISE AND FALL OF LAKE WAWASEE FROM JULY 6, 1895, TO NOVEMBER 1, 1896.



Spaces are units of inches.

Ten and one-half inches below zero of July 6, 1895, is lowest stage reached.
Thirteen and one-fourth inches above zero of July 6, 1895, is highest stage reached.

TABLE OF PRECIPITATIONS AT LAKE WAWASEE MEASURED IN RAINFALL INCHES FROM JULY, 1895, TO DECEMBER 1, 1896.

1895.	Inches.	1896.	Inches.	1896.	Inches.
July	2.10	January	1.35	July	8.93
August	2.35	February	1.55	August	5.19
September	1.53	March	2.55	September	4.54
October	1.59	April	2.51	October	.59
November	4.71	May	3.43	November	2.49
December	7.35	June	2.04	December	.

TABLE OF RISE AND FALL OF LAKE WAWASEE FROM JULY, 1895, TO DECEMBER 1, 1896.
Rise and fall measured in inches.

1895.	Loss.	Gain.	1896.	Loss.	Gain.	1896.	Loss.	Gain.
July	2.25		January		3.	July		7.5
August	2.		February		1.	August		4.75
September	2.5		March		1.5	September		.
October	3.75		April	.75		October		.
November		4.5	May	3.00		November.		.
December		7.5	June	2.25	3.00	December		

Total gain, 29.75 inches; total loss, 16.50 inches; net gain, 13.25 inches.

Year.	Month.	Day.	Thickness of ice in inches.	Temperature. 7 a.m.		Temperature. 5 p.m.	Direction of Wind.	Character of the Day.	Precipitation.
1895	December..	31	.375	10	to	34	W. S.	Clear.	
1896	January....	1	1.875	34		30	S. W.	Clear.	
		2	2.5	34		30	S. W.	Snow. Cloudy.	.09
		3	3.25	4		-2	W.	Partly cloudy.	
		4	5.5	-10	to	-2	W.	Clear.	
		5	7	2	to	14	W.	Snow. Cloudy.	
		6	7.5	12		20	S. E.	Clear.	.01
		7	7.5	16		27	S.	Partly cloudy.	
		8	8	28		30	S.	Clear.	
		9	8	32		36	S.W. to W.	Cloudy.	
		10	8	33		34	W. to S.	Clear.	
		11	7.5		36		S.	Clear.	
		12	7.75		22		W.	Clear.	
		13	8	17		22	W.	Partly cloudy.	
		14	8.25		20		W.	Snow.	Trace.
		15	8.75	20		22	N. to E.	Clear.	
		16	9.5	12		34	S. E. to S.		
		17	10	32		38	S.		

Year.	Month.	Day.	Thickness of ice in inches.	Temperature. 7 a.m.	Temperature. 5 p.m.	Direction of Wind.	Character of the Day.	Precipitation measured in Rain.
1896	January....	18	10	36	36	S.	Snow. Rain.	.09*
		19	10	32	38	W.	Partly cloudy.	
		20	10	31	34	S. to S. W.	Cloudy.	Trace.
		21	9.5	26	30	E.	Snow. Cloudy.	Trace.
		22	9	26	32	E.	Rain.	.30
		23	....	Rain.		E.	Rain.	.30
		24	....	Rain, snow.		N. E.	Rain and snow.	.36
		25	....	Rain, snow.		W.	Rain.	.10
		26	....	....	....	....	Cloudy.	
		27	9.5	26	32	W.	Clear.	
		28	9.5	30	32	S. W.	Cloudy.	
		29	9.5	36	46	S.	Clear.	
		30	....	32	56	S.	Clear.	
		31	....	36	39	S.	Rain.	.10†
1896	February...	1	....	39	32	W. to N. W.	Partly cloudy.	.......‡
		2	....	32	34	E.	Sleet. Rain.	.49
		3	....	32	34	E.	Snow. Rain.	.07
		4	....	29	33	S. W.	Snow.	Trace.
		5	....	32	36	S.	Snow. Rain.	.03

* Ice badly honeycombed.

† Heavy fog from 2 to 6 P. M.

‡ From 1st to 5th the rains soften the ice without diminishing its thickness perceptibly and melts the ice at the shore line.

Year.	Month.	Day.	Thickness of Ice in Inches.	Temperature. 7 a.m.	Temperature. 5 p.m.	Direction of the Wind.	Character of Day.	Precipitation.
1896	February...	6	9	33	30	N. to N. W.	Partly cloudy.	
		7	9	27	32	N.	Cloudy.	
		8	8.5	28	32	N. W.	Snow.	*
		11	9.5	23	28	W.	High wind all day.	
		12	....	20	26	S. E.	Snow, 6 inches.	.63
		13	....	22	28	N.	Snow, 1 inch.	.05
		15	9	40	30	S. to N.	Snow, cloudy.	Trace
		17	10	-1	20	N.	Clear.	
		18	11	22	22	N. W.	Snow, 2 inches.	.20
		19	....	6	0	W.	Snow, blizzard.	.02
		20	....	-2	8	W.	Snow, blizzard.	Trace
		21	11.5	-2	20	W.	Snow, blizzard.	
		22	12	18	40	S. to S. W.	Partly cloudy.	
		25	12	20	34	N. to S. W.	Clear.	†
		26	....	34	46	W.	Balmy, clear.	
		27	11	44	58	S.	Clear.	‡

*Ice growing strong and hard.
†Rain, 1 inch; fog on 23d.
‡Ice honey-combed.

Year.	Month.	Day.	Thickness of Ice in Inches.	Temperature. 7 a.m.	Temperature. 5 p.m.	Direction of the Wind.	Character of Day.	Precipitation in Rainfall, Inches.
1896	March.....	1	11	28	26	N.	Snow.	.45
		5	....	24	38	N. to E.	Rain, partly cloudy.	.35
		6	....	38	35	S. to N. W.	Snow.	Trace
		9	10	30	40	W. to E.	Snow, cloudy.	.15
		10	10	34	33	N. to N. E.	Snow, cloudy.	.10
		11	....	24	20	N. E. to N.	Snow, 2¾ inches.	.21
		12	12	1	15	W.	Snow squalls all day.	.01
		13	14	10	18	W.	Clear.	
		14	13	10	28	W.	Clear.	
		15	....	24	30	S. E.	Snow, 1$\frac{2}{10}$ inches.	.10
		17	12	26	36	W.	Snow, clear most of day.	
		18	....	32	36	S. W. to S. E.	Snow, cloudy.	Trace
		19	....	32	32	N.	Snow and high wind.	.22*
		23	10	28	33	N. to N. E.	Snow, ½ inch.	.03
		25	8	36	60	S. to S. W.	Cloudy, rain.	
		26	8	32	30	N. W. to N.	Snow.	†
		27	....	26	38	S. E.	Clear.	‡
		28	....	36	56	S.	Rain, th'd'r and lightn'g.	.71
		29	....	48	62	S. W.	Clear.	§

*High wind all day and night.
†Ice bursting and disintegrating.
‡Ice honey-combed and fractured.
§Ice driven out of lake.

Ice Formation Lake Wawasee. By J. P. Dolan.

In the season of 1895–6 there were two periods of ice formation, one beginning December 3 and terminating December 20; the other commencing December 31, 1895, and ending March 29, 1896. The first was fully described by Mr. D. C. Ridgley in his excellent report last year on the formation of ice, its effects on the shore line, and other kindred subjects relating to it, so that there is but little left to be said on these subjects in this paper.

From December 31 the ice continued to thicken till March 13, when the maximum thickness of fourteen (14) inches was attained, although there were brief periods of slight diminution, and, besides, the last three inches were additions rather than regular growth, being made up of partly melted snows.

After the 13th the disintegration was rapid. The rate of decrease from day to day, as well as the increase, is shown in the accompanying tables.

South and southwest winds prevailed from 24th to 29th, which, together with temperature ranging from 33° to 62°, swept the lake clear of all ice just four days later than the previous year.

March 8, 1896, the effects of the expansion of the ice were seen at their maximum. Ice along the shore at Pickwick, Kale Island, Epert's Vawter Park, Sharp's Bay and Wawasee a prominent ridge was pushed up, reaching in many places a height of six feet.

The force was most noticeable along the shore at Epert's, where for two hundred feet riprapping had been done to protect the low sandy and gravely embankments. This was all pushed back several feet and many of the largest bowlders lifted clear over the top of the five-foot ridge.

Across the entrance to the Gordonierre the effects were also marked, and again at Kale Island, though in less degree.

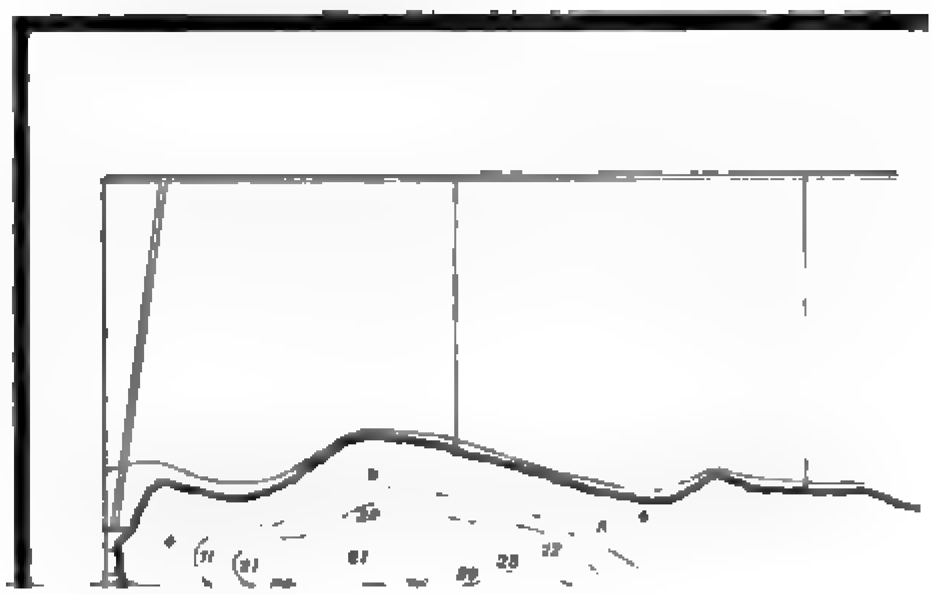
Photographs of these places were secured at the time.

Prior to 1895 the largest ice cracks observed were not more than three and one-half inches wide.

On January 18, 1896, a well marked, clean cut crevice ten inches wide and three hundred feet long was seen west of Blk. Stump Pt. The same day another four and one-half inches wide and five hundred and fifty feet long was observed northwest of the ten-inch crack just mentioned.

There was no suggestion of conformity to shore line in either of them; neither was there any similarity in their trends.

The only instance in which the cracks bore any seeming relation to the shore line was on lower Wawasee or Syracuse Lake, where a series of six wavy cracks



three-eighths of an inch wide, about twelve inches apart and one hundred feet long, were formed west of Weaver's Point.

In some instances the cracks seemed to be formed by an impact at right angles to the field as if some subaqueous cyclops had hurled a thunderbolt against the frozen mass and sent fractures in all directions from this point as center.

Off the Pickwick shore covering a large area the cracks were so numerous as to suggest a fine intricate mosaic. This will to some extent explain the readiness with which ice eight inches thick was removed by the wind and made to resemble slush in a few hours after it begins to move.

January 27, 1896, there occurred an unusual cracking of the ice, lasting all day and far into the night. A constant bursting, crashing and booming pervaded the whole lake. The noises suggested the crunching of heavy falling timbers and the hoarse roar of distant cannonading. The day was clear, sun shining most of the time, with temperature 26 to 34 degrees. The next day, with temperature 30 to 32, and cloudy, the lake was as silent as a cemetery.

After several days' moderately high temperature, during the last week of February the ice was well honeycombed. March 1st the temperature lowered to 26, accompanied by a high north wind and snow. The drifting snow was driven into the cells of the ice, making the whole field resemble a fine piece of oölite.

The Plankton of Turkey Lake.* By Chancey Juday.

The data for this preliminary report were collected during July and August, 1896, at Indiana University Biological Station. To Dr. C. H. Eigenmann, Director of the Biological Station, I am indebted for the plan of the net and for many helpful suggestions.

Hensen, who is the author of the term "plankton," applied this term to all plants and animals which are found floating free and which are carried about involuntarily by winds, waves, tides or currents. Haeckel extended the application so as to include all swimming and floating organisms. At present, however, those organisms that are not subject to the above-named physical forces are not considered plankton, and they shall not be dealt with as such in this report.

It has been demonstrated that a part of the plankton, the crustacea, furnishes nearly all the food of our most important fishes at a very critical period of their lives, that is, while they are very young fry (Forbes, 1889). This makes plankton a very important factor in the environment of these fishes. Its scarcity or abundance and the relative amount of crustacea will have much influence upon the

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*Contributions from the Zoölogical Laboratory of the Indiana University under the direction of C. H. Eigenmann, No. 19.

growth and development of the young fish. The plankton of Turkey Lake is here considered as an environment rather than as including a large portion of its inhabitants. As yet very little has been done toward classifying the various organisms composing it, but a great portion of it is crustaceans.

The net used in determining the quantity of plankton is essentially the same as those used by Hensen, Apstein and Reighard. The upper part consists of a truncated cone of canvas, supported by an iron framework. The diameter of the upper or smaller end of this cone is 33.35 cm. and of the larger or lower end 49 cm. The slant height is 36 cm.

The net proper is made of Dufour's No. 20 bolting cloth. It is a truncated cone with a slant height of 86 cm. The larger end is attached to the iron ring supporting the larger end of the canvas cone. To the smaller end is fastened a flat metal ring which supports the bucket. Three ropes attach this flat metal ring to the framework of the canvas cone. This relieves the net proper of the weight of the bucket. A twine net of inch mesh surrounds the net, serving to protect it and to remove as much strain from it as possible.

The bucket is a metal cylinder 6.5 cm. in diameter and 7 cm. deep. A flat metal ring is attached to the top. Through this pass three binding screws, which fasten the bucket to the ring on the bottom of the net. The sides of the bucket, except three narrow strips, are cut away, making three openings, 30 x 50 cm. These openings are covered with a wire gauze which has 77 per cent. of its surface solid and 23 per cent. open for the passage of water. The No. 20 bolting cloth has 83 per cent. of its surface solid and only 17 per cent. open for the passage of water. But an examination of water strained through each proved that the wire gauze is as effective a strainer as the cloth, and when water rich in plankton is forced through each by means of a pipette the gauze is the more effective strainer (Eigenmann, 1895). The bottom of the bucket is cup-shaped and has a small opening in the center. This opening is closed by a rubber stopper through which passes a short glass rod that enables one to remove the stopper conveniently. Three legs, each 10 cm. long, support the bucket.

Three ropes radiating from an iron ring are attached to the framework of the canvas cone and support the entire net. The rope which is used in drawing the net up is attached to this iron ring. This rope is measured off into feet or fractions of a meter, so the depth to which the net descends can be determined easily.

The plankton boat is provided with a swinging derrick in the stern. In the end of this derrick is a pulley through which the net rope passes. The derrick is high enough to allow the net to swing clear of the sides of the boat, so that the net may be swung into the boat after a haul has been made. (Eigenmann, 1895.)

In making a haul, the net is lowered slowly at first, so as to allow it to fill with water that has filtered through the bolting cloth. This prevents any abnormal amount of plankton which might occur if the surface water, rich in plankton, were allowed to fill the net without first being strained. The net is now lowered to the desired depth and hauled in hand over hand. The number of seconds required to raise it to the surface is noted. This will give the velocity, and from this the coefficient of the net, or its efficiency in straining, is calculated. The net is now raised out of the water, and while the process of filtering is going on some water is dashed against it so as to wash down any organisms that may be lodged on the inside. When the filtering process has progressed far enough, the binding screws are loosened and the bucket is removed. Filtering is now hastened by gently tapping the wire gauze with the hand. As soon as nearly all of the water has filtered out the bucket is placed over a small, glass-stoppered bottle which will hold about 250 cc., the rubber stopper is removed and the contents transferred to the bottle. The organisms that may be lodged on the sides of the bucket are rinsed into the bottle with filtered water. Enough 95% alcohol is now added to the contents of the bottle to give the whole a strength of 70%. This kills and preserves the organisms and facilitates the work by eliminating two or three steps which are necessary when some other killing agent is used. Besides, the organisms were found to be in a very good condition for qualitative work when killed and preserved in this way.

In measuring the quantity of plankton, a centrifuge manufactured by Richards & Co., of Chicago, was used. This is preferable to letting the material settle twenty-four hours, because it requires less time and puts the mass into a more compact form. This method also has an advantage in that it makes the measurements more uniform. If there is a large amount of light material in a haul, this will not settle very compactly in twenty-four hours, consequently the volume will be large. On the other hand, another haul may have a greater mass of material, but not yield such a large volume, because it is composed of material that will settle more compactly in the twenty-four hours.

Each bottle is permitted to stand an hour or so after it is taken to the laboratory. Some of the alcohol may then be removed without danger of losing any of the plankton. The remaining material is shaken up and poured into a graduated cylinder. The bottle is carefully rinsed and the rinsings added. The material is now thoroughly stirred with a small glass rod, so as to distribute the organisms equally throughout the liquid. The two sedimentation tubes, which are graduated to tenths of a cubic centimeter, are filled and placed in the metal cases of the centrifuge. The drive wheel is turned through 50 revolutions and the tubes are permitted to stand a few minutes so that the few small organisms that may

still be floating in the liquid may settle to the bottom; 50 more revolutions are given and the quantity of plankton is recorded. In all the measurements given in the table below only from 20% to 50% of each haul was actually measured. As a check upon this method several hauls were estimated and then the entire quantity measured. The differences were so slight that they might be accounted for by the small quantity of sand that is nearly always present. This would settle to the bottom of the graduated cylinder quickly, and would not be included when only a part of the haul is measured.

One revolution of the drive wheel of the centrifuge causes 31½ revolutions of the sedimentation tubes, and a hundred revolutions of the drive wheel are made in one minute. Thus in each case the plankton is subjected to 3,150 revolutions per minute, which is equivalent to a centrifugal force of about 391,680 dynes. In order to compare these results with those obtained by letting the material settle twenty-four hours, eight measurements were made by both methods. These show that the quantity obtained by the centrifuge is, on an average, only one-fifth of the quantity obtained by the other method. So it must be borne in mind that the results tabulated below must be multiplied by five in comparing them with results obtained by letting the material settle twenty-four hours.

The quantity of plankton taken at each haul does not represent the entire quantity in the column of water through which the net passes. Some of the water will be forced aside and the amount thus forced aside depends upon the velocity of the net. (Reighard, 1893.) That is, when the net is raised at a velocity of about 77 cm. per second, it will strain only half the column of water. In this case, to get the entire quantity of plankton, the amount taken must be multiplied by two which is the co-efficient of the net for this velocity. If the net is drawn slower more water is forced aside, hence a greater co-efficient. By plotting the results obtained by using the co-efficient for the observed velocity and that for the average velocity of the sixty hauls, it was found that the two curves differ very little except in two places and these represent hauls in which the velocity is very low. So it was deemed best to use the average velocity, 63.5 cm. per second, in computing results. The co-efficient of the net for this velocity is 2.215.

Also, to find the quantity of plankton under one square meter of surface another calculation is necessary. The area of the top of the net is 873.5 sq. cm. or a little less than one-eleventh of a sq. m. $\left(\frac{1}{11.448}\right)$. Thus, the quantity taken multiplied by the co-efficient of the net (2.215) and this by 11.448, or a total of 25.357, will give the amount of plankton under one sq. m. of surface. This result divided by the depth of the haul will give the quantity of plankton per cu. m. of water.

The tabulated results of the sixty hauls are as follows:

Time, 1896.			Haul.			Conditions of. Water.					Air.			Volume of Plankton in Cubic Centimeters.		
Month.	Day.	Hour.	Serial Number	Depth in Meters From Which Drawn.	Velocity in Meters Per Second.	Bottom.	Depth in Meters.	Temperature in Degrees Centigrade. Bottom.	Temperature in Degrees Centigrade. Top.	Surface.	Temperature in Degrees Centigrade.	Wind Direction.	Sky.	Taken in Vertical Net.	Calculated, Using Mean Velocity .635 meter per second. Under 1 sq. m. of Surface.	Calculated, Using Mean Velocity .635 meter per second. Per Cubic Meter of Water.
								Deg.	Deg.		Deg.					
July.	1	4.00 P.M.	I_1	4.5	.42	Muck	6.09	20.5	26	Moderate waves	27	S. E.	Clear	3.25	84.41	18.03
"	1	5.20 "	II_1	6.09	.41	Marl	8.8	20	26	"	27	S. E.	"	3.9	98.99	16.23
August	7	9.30 A.M.	II_2	6.09	.69	"	8.8	21	27.5	"	26.5	S.	Cloudy	4.72	119.8	19.68
"	7	9.50 "	II_3	6.09	.76	"	8.8	21	27.5	"	26.5	S.	"	3.3	83.67	13.74
"	7	10.10 "	II_4	3.04	.61	"	8.8	21	27.5	"	26.5	S.	"	5.17	131.09	43.1
"	7	10.20 "	II_5	3.04	.61	"	8.8	21	27.5	"	26.5	S.	"	4.15	105.38	34.6
July.	2	4.15 P.M.	III_1	19.2	.53	"	20.7	9.5	25	"	32	N. W.	"	2.75	69.73	3.63
August	21	9.15 A.M.	III_2	3.04	.51	"	20.7	14	25	Slight waves	25	S.	"	1.98	50.33	16.5
"	21	9.30 "	III_3	3.04	.61	"	20.7	14	25	"	25	S.	"	2.11	53.5	17.6
"	21	10.15 "	III_4	6.09	.66	"	20.7	14	25	"	25	S.	"	3.36	85.19	13.9
"	21	10.30 "	III_5	6.09	.66	"	20.7	14	25	"	25	S.	"	2.74	69.5	11.41
"	21	11.05 "	III_6	13.1	.71	"	20.7	14	25	"	25	S.	"	2.55	64.66	5.3
July.	10	2.10 P.M.	IV_1	6.09	.66	"	20.1	11	22	Smooth		S. W.	"	3.12	79.24	13.00
"	10	2.30 "	IV_2	6.09	.55	"	20.1	11	22	"		S. W.	"	2.74	62.75	10.3
"	10	3.00 "	IV_3	6.09	.35	"	20.1	11	22	"		S. W.	"	3.23	82.08	13.47
"	10	3.20 "	IV_4	6.09	.55	"	20.1	11	22	"		S. W.	"	2.67	67.77	11.12
"	20	10.00 A.M.	IV_5	6.09	.71	"	20.1	11	21.5	Rough	22	N. W.	"	3.22	81.77	13.42
"	20	10.15 "	IV_6	15.2	.76	"	20.1	11	21.5	Quite rough	22	N. W.	"	2.53	64.34	4.22
"	20	10.30 "	IV_7	3.04	.51	"	20.1	11	21.5	"	22	N. W.	"	2.51	63.84	21

CONDITIONS OF—Continued.

Time, 1896.			Haul.			Water.						Air.			Volume of Plankton in Cubic Centimeters.		
Month.	Day.	Hour.	Serial Number.	Depth in Meters From Which Drawn.	Velocity in Meters Per Second.	Bottom.	Depth in Meters.	Temperature in Degrees Centigrade. Bottom.	Temperature in Degrees Centigrade. Top.	Surface.	Temperature in Degrees Centigrade.	Wind Direction.	Sky.	Taken in Vertical Net.	Calculated, Using Mean Velocity .635 meter per Second. Under 1 sq. m. of Surface.	Calculated, Using Mean Velocity .635 meter per Second. Per Cubic Meter of Water.
								Deg.	Deg.		Deg.					
August	6	10.50 A.M.	IV	18.2	.76	Marl	20.1	14.5	28	Moderate waves	31	S. W.	Broken Clouds	4.1	103.9	5.69
"	6	11.10 "	IV	6.09	.68	"	20.1	14.5	28	"	31	S. W.	"	4.74	120.19	19.73
"	6	11.25 "	IV	6.09	.68	"	20.1	14.5	28	Slight waves	31	S. W.	"	4.27	107	17.6
"	17	3.30 P.M.	IV	6.09	.76	"	20.1	16	26.5	Rough	23	N. W.	Cloudy	3.91	99.27	16.3
"	17	3.45 "	IV	6.09	.68	"	20.1	16	26.5	"	23	N. W.	"	2.75	69.73	11.4
"	19	9.50 A.M.	IV	6.09	.76	"	20.1	15.5	25	Moderate waves	16.5	N. E.	Clear	5.85	148.3	24.3
"	19	10.15 "	IV	6.09	.76	"	20.1	15.5	25	"	16.6	N. E.	"	3.86	97.87	16
"	19	10.25 "	IV	6.04	.68	"	20.1	15.5	25	"	16.5	N. E.	"	4.24	107.5	17.6
"	20	2.25 P.M.	IV	6.09	.68	"	20.1	15	25	Slight waves	25.5	S.	"	2.82	71.6	11.76
"	27	11.00 A.M.	IV	6.09	.61	"	20.1	16	23	Moderate waves		N. W.	Cloudy	1.62	41.2	6.7
July	20	11.00 "	V	1.5	.43	Muck	2.4	21.5	21.5	Slight waves	22	N. W.	"	1.5	38	25
"	20	3.30 P.M.	VI	6.09	.76	Marl	11.27	18	22	Moderate waves	24	W.	Broken clouds	2.23	56.5	9.28
"	20	3.45 "	VI	6.09	.61	"	11.27	18	22	"	23	W.	"	2.17	55.15	9.05
"	20	4.30 "	VII	9.14	.30	Sand	1.8	22	22	"	23	W.	"	1.51	38.3	41.8
"	21	9.27 A.M.	VIII	2.1	.71	"	3.2	22	22	Smooth	23.5	S. W.	"	1.8	45.6	21.4
"	21	10.00 "	IX	6.09	.76	"	13.1	15	23	"	24	S. W.	"	2.5	63.3	10.4
August	3	2.37 P.M.	X	7.62	.76	Marl	10	19	25	Slight waves	27	S. W.	"	6.17	156.5	20.5
"	12	2.00 "	X	6.09	.68	"	10	21	29	"	26.5	E.	Cloudy	6.52	165.3	27.1
"	12	3.00 "	X	6.09	.68	"	10	21	29	"	26.5	E.	"	5.42	137.5	22.5
"	12	3.20 "	X	3.04	.55	"	10	21	29	"	26.5	E.	"	7.75	196.5	64.6
"	7	11.20 A.M.	XI	6.09	.76	"	7.3	23	26.5	"	26	S. E.	"	5.17	131.2	21.5

"	7	11.30 "	XI_2	6.09	.76	"	7.3	23	26.5	"	28	S. E.	"	3.6	91.2	14.9
"	7	3.00 P.M.	XII_1	1.37	.46	Sand	2.1	26.5	28	"	28	S.	"	3.41	86.5	66.1
"	7	3.20 "	XII_2	1.37	.55	"	2.1	26.5	28	"	28	S.	"	2.76	70	51.1
"	8	10.00 A.M.	XIII_1	6.09	.68	Marl	14	16	28	Moderate waves	29	S.	Hazy	4.9	124.2	20.4
"	8	10.10 "	XIII_2	6.09	.71	"	14	16	28	"	29	S.	"	4.68	118.8	19.5
"	8	10.25 "	XIII_3	3.04	.61	"	14	16	28	"	29	S.	"	6.5	164.8	54.2
"	8	10.40 "	XIII_4	3.04	.61	"	14	16	28	"	29	S.	"	4.59	116.4	38.3
"	8	11.00 "	XIII_5	1.5	.48	"	14	16	28	"	29	S.	"	3.85	97.6	64.2
"	12	10.20 "	XIV_1	1.5	.51	Muck	3.3	27	29	Calm	25.5	E.	Cloudy	8.2	207.9	136.8
"	12	4.00 P.M.	XV_1	1.8	.45	"	3.04	28	30	"	26.5	None	"	4.8	121.7	80
"	17	9.00 A.M.	XVI_1	9.14	.61	Marl	10.6		26.5	"	23	"	Clear	3.39	85.9	9.4
"	17	9.35 "	XVII_1	2.1	.60	Sand	3.04	26	26.5	"	23	"	"	4.5	114.1	54.3
"	17	9.45 "	XVII_2	2.1	.70	"	3.04	26	26.5	"	23	"	"	4.11	104.3	49.7
"	17	10.50 "	XVIII	3.04	.61	"	4.5	26	27	Slight waves	23	N. W.	Cloudy	4.8	121.7	40
"	17	11.45 "	XIX_1	3.04	.61	"	4.5	26	27	"	23	N. W.	"	4.09	103.8	34.1
"	21	3.30 P.M.	XX_1	6.09	.61	Marl	13.3	19	25.5	Moderate waves	28	S.	"	1.8	45.6	7.49
"	21	4.00 "	XX_2	6.09	.76	"	13.3	19	25.5	"	28	S.	"	2.39	60.7	9.98
"	21	4.15 "	XX_3	9.14	.70	"	13.3	19	25.5	"	28	S.	"	1.72	43.7	4.78
"	25	4.15 "	XXI_1	6.09	.76	Muck	7.3	23	24.5	"	26.5	S. W.	Hazy	1.71	43.3	7.12
"	25	4.30 "	XXI_2	6.09	.68	"	7.3	23	24.5	"	26.5	S. W.	"	1.91	48.5	7.97

In the table the stations are indicated by Roman numerals and the number of the haul by Arabic. The other points are self-explanatory.

The twenty-one stations are quite widely distributed, as the accompanying map will show, so as to include as many of the various conditions as possible. To see whether local variations affect the distribution of plankton, two or more hauls were made at the same station as nearly under the same conditions and in as quick succession as possible. Following Apstein, the mean for the hauls thus made is taken, and the per cent. of variation of each haul from this mean is calculated. The results are shown in the following table:

NUMBER OF HAUL.	Depth of Haul.	Volume per Sq. in. of Surface.	AVERAGE.	Per cent. of Variation from Average.
II$_1$	6.09	98.89	100.81	1.9
II$_2$	6.09	119.88		15.9
II$_3$	6.09	83.67		20.4
II$_4$	3.04	131.09	118.23	9.8
II$_5$	3.04	105.38		12.1
III$_2$	3.04	50.33	51.94	3.1
III$_3$	3.04	53.56		3
III$_4$	6.09	85.19	77.34	9.2
III$_5$	6.09	69.50		11.2
IV$_1$	6.09	79.24	72.96	7.9
V$_2$	6.09	62.75		16.2
IV$_3$	6.09	82.08		11.1
IV$_4$	6.09	67.77		7.6
IV$_9$	6.09	120.19	113.61	5.4
IV$_{10}$	6.09	107.04		6.1
IV$_{11}$	6.09	99.27	84.5	14.8
IV$_{12}$	6.09	69.73		21.1
IV$_{13}$	6.09	148.33	117.9	25.1
IV$_{14}$	6.09	97.87		20.4
IV$_{15}$	6.09	107.51		9.6
VI$_1$	6.09	56.57	55.86	.12
VI$_2$	6.09	55.15		.12
X$_2$	6.09	165.32	151.44	8.3
X$_3$	6.09	137.56		10
XI$_1$	6.09	131.22	111.25	15.2
XI$_2$	6.09	91.28		21.8
XII$_1$	1.37	86.53	78.28	9.5
XII$_2$	1.37	70.04		11.7
XIII$_1$	6.09	124.24	121.55	2.1
XIII$_2$	6.09	118.86		2.2
XIII$_3$	3.04	164.82	140.65	14 6
XIII$_4$	3.04	116.48		20.7
XVII$_1$	2.1	114.10	109.24	4.2
XVII$_2$	2.1	104.38		4.6
XX$_1$	6.09	45.64	53.21	16.5
XX$_2$	6 09	60.78		12.4
XXI$_1$	6.09	43.36	45.95	5.9
XXI$_2$	6.09	48.55		5.3

Thus 9 hauls vary between .12 per cent. and 5 per cent.; 12 between 5.1 and 10; 7 between 10.1 and 15; 4 between 15.1 and 20, and 5 between 20.1 and 25; 1 haul varied 25.1 per cent.

Eighty-four per cent. of the 38 hauls do not vary more than 20 per cent and only one over 25 per cent. This variation is slightly greater than in the results obtained by Apstein and Reighard.

Station IV was selected for the purpose of studying changes in distribution from day to day by making daily hauls, but this plan was not carried out. However, five hauls were made here in July and eight in August at a depth of six meters. Those made in July have an average of 12.26 cc. of plankton per cu. m. of water, while the eight made in August have an average of 16.86 cc. per cu. m. of water. This increase of 4.6 cc. is due to the natural seasonal variation, as Apstein (1892) found that there is a rapid increase in the quantity of plankton during August and September, reaching a maximum about the 1st of October.

Turkey Lake is comparatively rich in plankton. Dobersdorf See, which is classed as "plankton rich" by Apstein, contained in July, 1892, 1,062 cc. of plankton under one sq. m. of surface at a depth of 20 m., or 53 cc. per cu. m. of water. One haul (III) in Turkey Lake, July 2, shows that it contained 348.6 (69.73 x 5) cc. under one sq. m. of surface at a depth of nearly 20 m., or 18.15 cc. per cu. m. of water. Thus Dobersdorf See contained not quite three times as much plankton. In comparison with other North American lakes, Turkey Lake has from thirty to fifty times as much plankton in August as Reighard (1893) found in Lake St. Clair in September, and from fifteen to twenty times as much as Ward (1894) found in Lakes Michigan, Round and Pine at the same depths and during the same month, August.

A surface stratum about three meters deep contains most of the plankton of Turkey Lake. The average number of cc. per cu. m. of water for the ten hauls made at a depth of three meters is 36.4, for thirty-one hauls made at a depth of six meters it is 14.8. By means of a pump, a piece of rubber hose, and a small net of No. 20 bolting cloth, it was found that very few organisms live below a depth of six meters and scarcely any but Oligochetes below fifteen meters. Three hauls (III_6, IV_8, XX_3) present some difficulties which are still unexplained. They are hauls from a depth greater than six meters, and show a smaller quantity of plankton actually taken than hauls made just before or immediately after at a depth of six meters. This difficulty was not noticed, however, in time to make further hauls in the same manner to see if an explanation might be found. The unusually large quantity taken in hauls XIV and XV is probably due to a local accumulation, as the wind on the previous day was of such strength and from the proper direction to cause such.

To sum up—

1. The plankton of Turkey Lake is quite uniformly distributed.

2. It is the richest in plankton of any of the North American lakes which have so far been examined, and compares favorably with what are termed "plankton rich" lakes.

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Physical Survey of Lakes Tippecanoe, Eagle, Webster and Cedar. By Thomas Large, Assisted by C. O. & A. D. Fisher.

The method of measurement in this work was the same as that employed by Messrs. Juday and Ridgley and myself last year in the survey of Turkey Lake, differing only in an attempt to follow such established lines as section lines, quarter and half-section lines, which are usually indicated by farm fences, and, therefore, can be readily found, and are thus permanently marked. Profiting by the experience of the previous year, we made but few cross lines, as they are very confusing, particularly when made in rough weather.

Three of the lakes sounded this year are parts of the Tippecanoe drainage system—that river flowing through Lakes Webster and Tippecanoe, and being connected with Eagle Lake by a small stream. Cedar Lake has for its outlet a small stream flowing to the Kankakee River. Of these lakes Tippecanoe is the largest,

least known and retains most nearly its primitive condition. No damming or draining have in any way affected it. The principal alterations by man being the removal of the largest trees from its shores for lumber, and clearing of eight tracts for farming, which border it in its twelve and three-fourths miles of shore line. Did we know that the government surveyors in 1834 had followed the shore faithfully, we could now draw some conclusions of value concerning the rapidity with which this basin is filling. I have good reasons to believe, however, that those surveys can not be depended on for such work. The area, as computed for the lake by the "weighing method" used last year, is 1.41 square miles.

The amount of marsh land about the shore is very much less, comparatively, than that about Turkey Lake. This may be accounted for by the fact that Tippecanoe lies in the middle of a system rather than at the head, as in the case of the former. The low wooded hills come quite close to this lake at almost all points excepting the eastern end on the north and south sides. It is in three basins: James Lake, of about a half square mile area at the east end connected by a channel through swamp to the main lake, which is of about one and one-half square miles in area, and Oswego Lake, below, also connected by a channel, and having an area of about thirty acres. The channels are usually about four feet in depth and are much frequented by minnows and young fish. Here and in the mouths of streams are found the pond-lily plants (*Nymphea*) and spatter-dock (*Naphur*), the root-stalks being in many instances four or five inches in diameter and usually washed bare and shining. They were roasted and used for food by the Indians; remains of pits lined with boulders and used for this purpose are yet found on the south shore near "Indian Furnace Point."

This lake being greater in general depth (the greatest depth found is 121 feet in the main lake) than any of the others, Turkey included, has less of the aquatic vegetation than they. Bullrushes and bladderwort (*Utricularia*) not seeming to thrive in water more than eight or ten feet in depth, and these are usually the advance guards of the vegetable encroachments.

Eagle Lake being second of those under consideration in general depth stands next to Tippecanoe fewest in water plants. As Prof. S. Coulter is investigating the conditions of life there I gladly leave that in his hands.

The measurements of Eagle Lake are as accurate as those of the others, but owing to a flood at the time the work was done much that would be of interest was inaccessible. It will be noticed from the map that the lake consists of a main body of water of almost a square mile in area and a small bay on the west side connected by a shallow channel. The outlet is a small stream from the south end of this bay. Two creeks and several springs on the east shore contribute water to

this lake. The amount of marshy land is small, lying principally at the southeast end near the outlet.

The margin of the lake, according to the government survey (1834), is at some distance from the present shore line, but I am inclined to think that that only marked the edge of marshy ground, since at many points within this line are quite large trees growing. I have not been able to obtain accurate information concerning this matter. The greatest changes made in the form of this lake are by the construction of a race-track by filling in a part of the lake on the east side and excavation of a canal from the northwest part of the bay to a point near the railroad depots. We are indebted to the members of the Winona Summer School for boats for our work and admission to the grounds at the time we were making soundings. The area is .987 square mile.

Webster Lake has been more changed than either of the others by human agencies. It was formerly a group of two or three lakes of about thirty-five feet at their deepest point, lying in the positions indicated by the dotted lines on the accompanying map, surrounded by a marsh of about the extent of the present lake. A dam was constructed for water power for a flouring mill, and this raised the water to seven feet above its former level. In the north part of the lake numerous stumps of various sizes indicate the position of a shore line. "The Backwater" was entirely produced by this dam. The total area at present is 1.057 sq. miles.

This lake presents a greater diversity than either of the others; being shallow, it has great abundance of water plants, the "Backwater" being literally crowded with splatterdock and pond lilies. It has eight wooded islands and shore with variety of meadow, wood, marsh and hill. On the shore also is a variety in vegetation. The edge of the backwater in many places is crowded with cat-tails, while a bog of about five acres in extent at the most northern part of this bay was covered with pitcher plants (*Sarracenia purpurea*), and on a ridge somewhat farther east was found a considerable diversity of fungus growth. The marsh at the northeast part of the main lake was peculiar because of the height of the quaking, grass-grown bog. In two places it was almost twelve feet in height and quite near the lake. Lying behind this was bog lower than that mentioned. I can not account for this formation satisfactorily, unless it is caused by powerful springs of water beneath making deposits there.

An instance where springs have built up bog to a greater height is to be seen at the northeast of "the backwater" on either side of a gravelly ridge, but here the water may follow the ridge out from the higher ground.

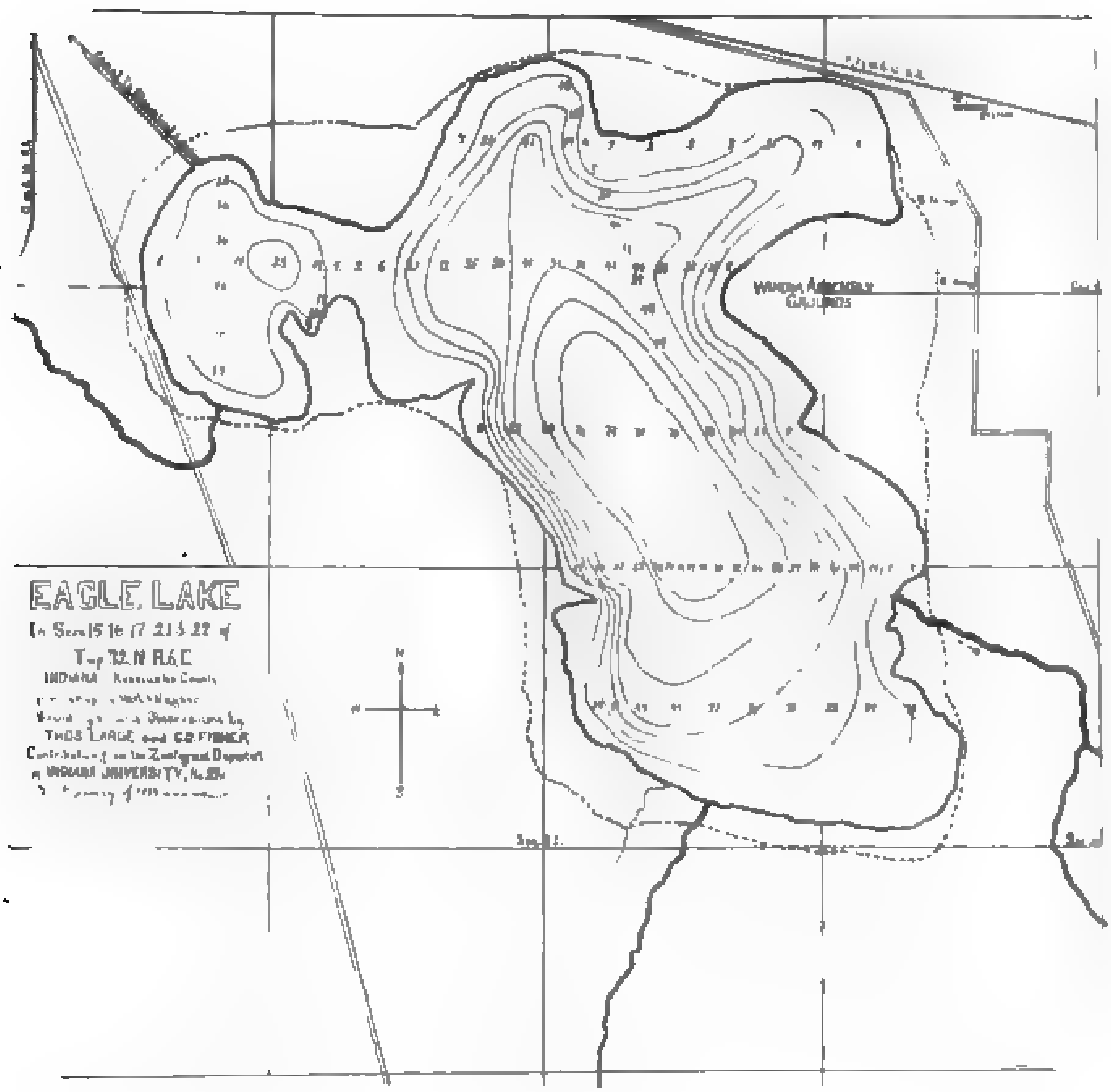
A noticable thing about all of the Tippecanoe lakes in contrast to the Turkey Lake is the amber appearance of the water, given, perhaps, by the bogs from

whence it flows. In Turkey Lake the water has a clear, almost greenish appearance. The measurements of inflow and outflow taken will have no value, because of the swollen condition of the streams at the time they were taken.

Cedar Lake (or Clear Lake of the Government Surveys, also "The Lake of the Red Cedars") is a shallow, regular body of water having a more than ordinarily uniform slope of basin, and in no place exceeding twenty feet in depth. About its shores are wooded hills which in almost every part come very near the shore, the south end excepted. Here there is some marshy land. At the north end the hills reach a height of sixty feet. They are a part of the moraine which separates the Mississippi and St. Lawrence valleys. Within a fourth of a mile from the north end of the lake is a narrow ridge 150 feet in length, 30 feet wide and 8 feet high, in appearance very like a railroad embankment, which crosses a narrow hollow and divides the waters which flow into these two systems. To the north of it is a swamp of perhaps fifty acres in extent, extending to the ridge. On the south side a narrow channel twenty feet in width, choked with grasses, etc., but still with stagnant water in it, starts a few feet from it; further down the soil has washed in and closed it, except for a narrow stream. The whole appearance of the ridge is that it is very recent formation, but I am informed it was there when the white men came. The moraine at the north, the appearance of a wide valley to the southward and the shallowness of the lake make the conclusion almost irresistible that this lake basin has been formed by the washing of the water of the melting glacier which has rested on the north of it, as the water found its way to the Kankakee. The present outlet is by a small stream flowing past the town of Lowell to the southeast into the Kankakee.

The ice beaches on this lake are larger than those of any other I have noticed. On the north is a ridge of sand, probably formed in this way, 1,000 feet long, 35 feet wide, and about 7 feet high in the highest part. On the east side are two others, but much less conspicuous. The bottom of the lake is generally sand. Vegetation is less abundant than generally in the shallow lakes in the eastern part of the State. The muskrat is very abundant, building, according to its habit, reed houses in the fall in great numbers at a little distance in the lake. At the northwest side near the end of the great sand ridge was found an Indian mound. This had been opened and a number of skeletons found in it. On top of it grew formerly an oak tree showing almost 200 "growth marks."

I am under obligations to Rev. Timothy Ball, of Crown Point; Dr. Herbert S. Ball, of Crown Point; Mr. A. D. Fisher, of Indiana University, and the Monon Railroad Company for valuable assistance, information, etc. My report of this lake would be very meager indeed had I not received the assistance from the gentlemen at Crown Point.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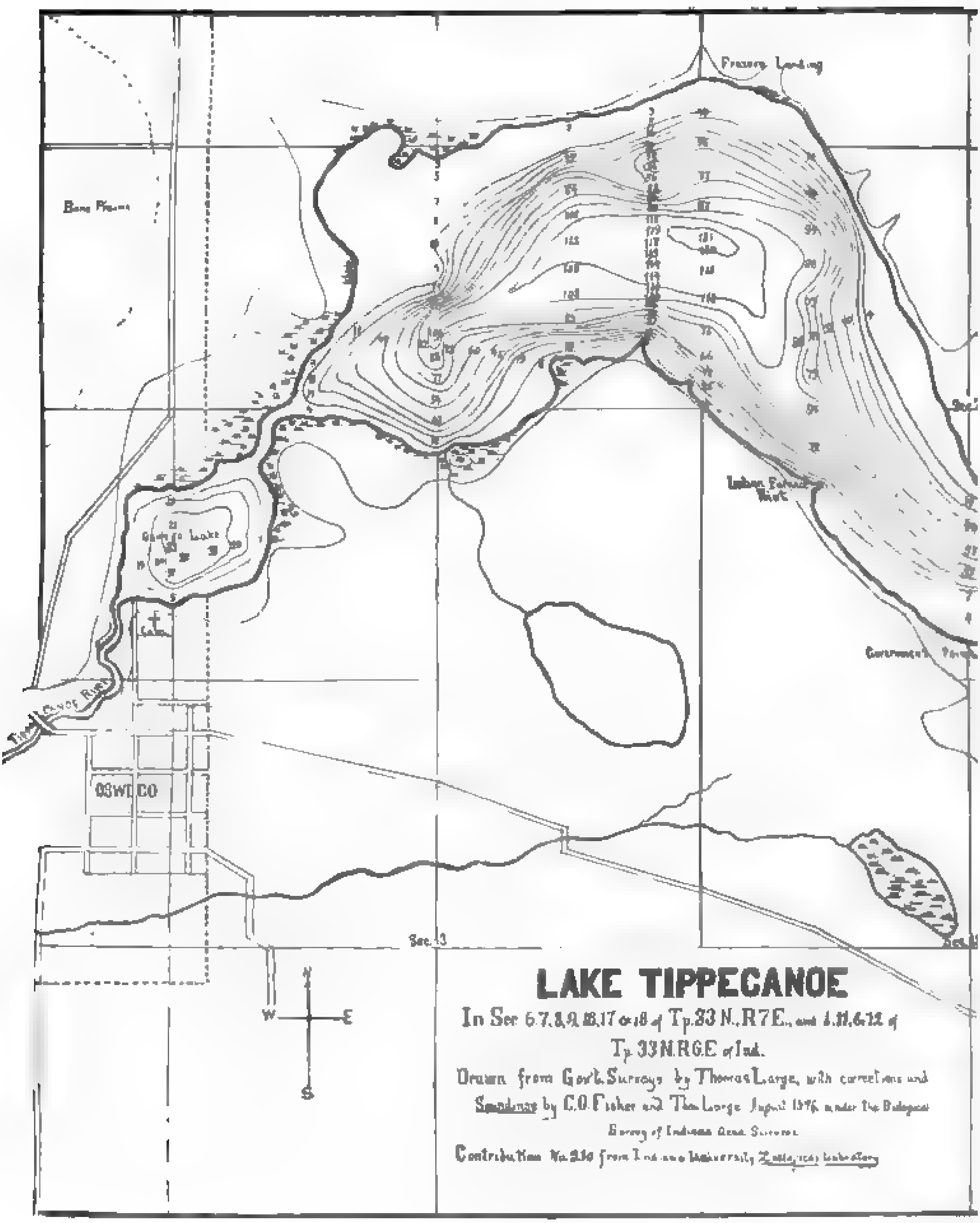
WINONA ASSEMBLY GROUNDS


Frazers Landing
OSWEGO
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E
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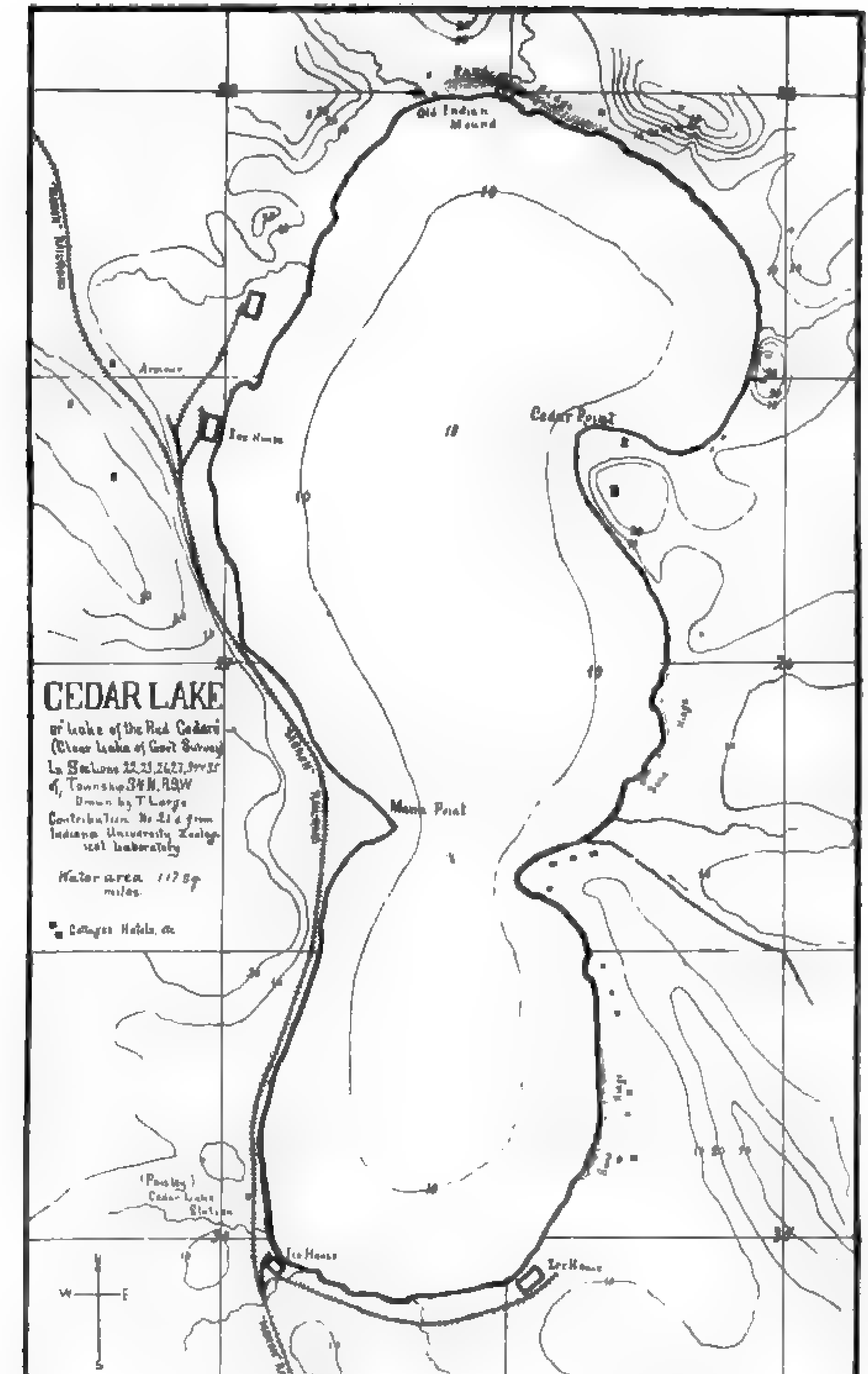
LAKE TIPPECANOE
Drawn from Gov't. Surveys by Thomas Large, with corrections and
by C.O. Fisher and Thos Large August 1896 under the Biological
Survey of Indiana
Contribution No. 210 from Indiana University Zoological Laboratory


CEDAR LAKE
Drawn by T Large
Old Indian Mound
Cedar Point
Ice House
Ice House
Ice House
Cedar Lake Station
Water area
Cottages Hotels, &c
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THE DESTRUCTION OF A SCHOOL OF BLUE GILLS. BY THOMAS LARGE.

On August 14, 1896, Mr. A. J. Chapman, while standing on the bridge across the channel between the main lake and the backwater bay of Webster Lake, noticed immense schools of Blue Gills (*Lepomis Pallidus*)—among which were but very few other fish—passing toward the main lake. On the days just preceding this the temperature had risen the highest of any other period of the summer, and Mr. Chapman states that the water-gates of the grist mill at Boston, Ind., a few miles up the Tippecanoe River, had been closed, and caused the water below to fall to a lower level than usual. None of the water of this part of the lake is more than five or six feet in depth, and much of it much shallower. The water became very much heated, and if this is the correct explanation of this movement, these fish can not endure a great change in temperature, hence migrated to the deeper water below. By opening the water-gates, a current being re-established and the lake rising to its usual level, the fish attempted to return to their usual feeding ground, and a large part of them lost their way in the lily-pads and spatterdock which line either side of the narrow, winding channel, and, coming into the shallow water near the shore on the east side, just below the bridge, were killed by the great heat of the water there.

Four days later, when I visited this place and found the dead fish and received the substance of the above explanation from Mr. Chapman, the margin of the lake for about ten rods was thickly covered with dead fish. Among them, as before stated, were very few other fish—one or two bass and a catfish being all that I found. There was a considerable uniformity in size, ranging from three to five or six inches in length. They had been fly-blown, and were almost entirely destroyed, excepting bones, scales and skin, and the road at a distance of a dozen feet was literally covered with maggots. The stench was great.

I have no better explanation to offer than the one given above, but noticed on entering the channel, almost a half mile below, a film on the water, such as one sees where organic matter decays, and noticed an odor different from that near the fish. In the water were masses of decaying bladderwort (*Utricularia vulgaris*), which might have been killed by the heat, and its presence in the water might have caused the migration.

The Fovea. By J. R. Stonaker.

In a brief discussion of a subject like this one can but touch upon a few of the many interesting and important points which present themselves in a careful study. The following is mainly an abstract of a paper that will appear soon in a number of the "Journal of Morphology" under the heading of "A Comparative Study of the Area of Acute Vision in the Vertebrates," to which any one is referred who may desire a more thorough and systematic treatise on this subject.

The term *Fovea* comes from the Latin, and means a pit or depression. It is in this sense that I have used it, and not as the point of acute vision in any eye. The significance of this statement will be readily seen when you consider the fact that many animals do not possess such a pit or fovea, but do have an area of most acute vision. However, when a fovea is present it *is* the point of most acute vision.

Before giving a minute description of the fovea a few words concerning its embryological development may be desirable.

J. H. Chievitz, a German investigator, has done a great deal on this subject. He finds that there is first developed, in the place where the fovea afterwards appears, a thickening of the retina. This thickening he terms the "Area centralis." It is present in the human fœtus about the sixth month, after which time the fovea begins to appear. This increase in thickness is due largely to an accumulation of cells in three layers, viz.: the nerve cell layer and the inner and outer nuclear layers. Then follows a gradual pitting in of the vitreal surface, due to a thinning out or pushing toward the periphery of the elements of all the layers of the retina excepting the rod and cone and the pigment layers. This development has proceeded in some animals only to the formation of an area, in others to a very shallow fovea; while many have a very deep and well-defined depression. In a very shallow fovea all the layers may be present in the center, though somewhat thinner; but in the center of a deep fovea some of the layers will be entirely absent, and those which remain very much reduced, excepting, of course, the rod and cone and the pigment layers. The layer which disappears first is the nerve fibre layer. Then follow the nerve cell layer, inner molecular layer, inner nuclear layer, and, in a very deep fovea, the outer molecular and nuclear layers may also be wanting. This is readily seen in the foveæ of the turkey, pigeon, robin, hawk or human. We thus have a fovea developed which is always surrounded by an area, or, in the terms of human physiology, a macula lutea.

As one approaches the fovea the rods and cones have less diameter, and are more numerous per given area. This necessitates an increase in the number of cells which form the connection with the nerve fibres (ganglion or nerve cells and cells of the inner and outer nuclear layers). But this is not the only cause for an increase in number of these cells. Raymon y Cajal has carefully worked out the manner in which these cells form the connection between the rods and the cones and the nerve fibres. In general, processes pass outward (dendrites) from the ganglion cells and branch profusely among the ingoing processes (neurites) from the cells of the inner nuclear layer. A similar relation obtains in the outer molecular layer between the dendrites and the neurites of the cells of the inner and outer nuclear layers. Each ganglion cell, and consequently each nerve fibre, comes in contact with from ten to thirty rods or cones. But in the region of the area the dendrites and neurites of these cells branch less and finally reach that condition in the center of the fovea where each ganglion cell is in contact with but a single cone.

In the peripheral part of the retina the rods generally exceed the cones in number, but as one approaches the area or fovea the cones become more numerous, and finally in the center of the fovea the rods are entirely wanting.

The fovea varies greatly in form, number and position in different animals. It varies from a very questionable depression found in the domestic guinea hen to a very sharp and deep funnel-like pit found in most birds, especially birds of prey, and in many lizards. The depression may be very broad, as seen in man and some fishes; or, according to Chievitz, we may have a trough-like fovea of various depths, extending horizontally across the retina. In my researches I have not been able to find such a fovea. It is true that in many birds I have seen what appears, to the unaided eye, to be a trough-like depression, but when sections were made across such a region and examined microscopically such a fovea was not discerned. I have been able to examine but one of the species which he has mentioned as having this peculiar fovea, so have included them in my tabulation as he has described them.

As a rule but one fovea is present, but twelve birds have been examined in which two distinct foveæ have been found. Chievitz has described some as having also a trough-like fovea. A double fovea has been discovered only in birds. Among those which I have found to possess double foveæ are three species of hawks, the white-bellied swallow, the common tern and the kingfisher.

The position of the fovea may be either on the nasal side of the entrance of the optic nerve (fovea nasalis), as in most birds, or it may be situated on the temporal side (fovea temporalis) as in man and the owls. The fovea nasalis

occupies about the central point of the retina and functions only in monocular vision. The temporal fovea functions in binocular vision. In man it is located about the center of the retina, but in the owl it is some distance to the temporal side of the center. In the case of two foveæ, the one at the center of the retina (fovea nasalis) functions in monocular vision; the other (fovea temporalis) corresponds in position to that of the owl, and functions, likewise, in binocular vision. If a trough-like fovea is present it would function in acts of sight anywhere between monocular and binocular vision.

The area centralis also has a variety of forms, number and positions corresponding to those of the fovea and similarly named. A simple fovea is always surrounded by a round area which is frequently on or in a band-like area extending horizontally across the retina. If a trough-like fovea should be present it would lie along a band-like area. Frequently when two foveæ are present the areas surrounding each are connected by a band-like area.

We may thus have various combinations of area and fovea. The most common is a simple fovea surrounded by a round area. Further, this round area may be continuous with a band-like one. Or two foveæ may each be surrounded by a round area, one of which may be continuous with a band-like area, or each may be so connected.

When one considers the prevalence of a fovea in the different vertebrates he finds that, though each class has representatives which possess a fovea, by far the greater number have only an area centralis. Many have been examined in which not even an area has been observed.

The following tabulation represents in a condensed form the results, so far as I have been able to collect them, of all investigations up to the present time:

	No. of Species.		No. Area Found.	Area Found.		Fovea Found.		
				Round.	Band-like.	Simple.	Trough-like.	Double.
	51	Mammals	10	33	8	18	...	......
	104	Birds	......	104	36	91	22	12
	28	Reptiles	3	23	3	8	2	.....
	14	Amphibians	3	3	8	1	1	.....
	30	Fishes	10	20	....	5	......	.....
Total	227		26	183	55	123	25	12

Of all the animals which I have been able to tabulate (227 species) no area was found in 26, a round area was perceived in 183, and a band-like area in 55. Of this number, 120 possessed a simple fovea, 12 a double fovea, and according to Chievitz 25 had a through-like fovea.

Mammals do not as a rule possess a fovea, but generally have an area. Of the 51 species tabulated 10 were found in which no area was demonstrated; 33 had a round area and eight a band-like area. Only 18 species (all primates) possessed a well-defined fovea.

In the 104 birds all had a clear fovea excepting one, the common chicken. Why the chicken does not have a fovea when it is present in all the nearest allied forms remains a query. A round area was found in every case, and in 36 a band-like area was also observed. Ninety-one had a simple fovea, twelve double fovea, and twenty-two the questionable trough-like fovea.

Among reptiles a well-defined fovea has generally been found in the lizards and crocodiles, but it has not been observed in the snakes and turtles. Of the twenty-eight species examined only three were found which did not possess an area, while twenty-three had a round area and three band-like ones. A round fovea was seen in the lizards tabulated and a trough-like fovea in the crocodiles.

A fovea has been observed in only two of the fourteen amphibians tabulated. Chievitz reports a trough-like fovea in *Bufo calamita* and Hulke a simple fovea in *Bufo vulgaris*. I have not found a fovea in any of the amphibians which I have examined. In the tabulation, three of the number had no area, three had a round area, and eight possessed a band-like one. I have found the band-like area common to frogs and toads.

In fishes the absence of a fovea is the rule. In the thirty species given a fovea was observed in but five, and no area in ten. In these ten, however, the material at hand was not sufficient to warrant a definite statement. Of the twenty-six fishes I have examined only one was found with a fovea. This was the pipe fish (*Siphostoma fuscum*).

When one compares the retinas in the different vertebrates he finds a marked diversity. A great difference is noticed in the relative thickness of the different layers. But the most marked change is noticed in the rod and cone layer. Comparing the diameter, length, shape and relative number of the rods and cones we find that fishes, frogs and mammals possess the longest rods. In mammals the rods have the smallest diameter, and in frogs the greatest of any of the vertebrates. In birds they are comparatively short and thick. The cones are the longest in some of the reptiles (chameleon) and of greatest diameter in amphibians and mammals. They have about the same length in birds and am-

phibians, while in fishes they are the shortest. In birds the diameter of the cones approaches very closely to that of the reptiles.

When one is comparing the sensitiveness of the retina of different animals the diameter of the rods and cones is of vast importance. For since these sensitive elements are arranged close together, where the diameter is small there would be more per given area and a more sensitive retina.

The relative number of rods and cones is also of importance. In mammals and amphibians the rods far surpass the cones in number. In birds, with few exceptions, the reverse is true, while in reptiles few or no rods are present. In fishes they are more equally divided.

Investigations by experiment and histological examination prove that the rods are more sensitive to faint impressions than the cones, but that the cones have the greatest power of discrimination both of color and shade. Most nocturnal animals that have been examined have few or no cones.

Experiments on the human retina show that the fovea has the power of most acute vision, and that the power of distinct vision grows rapidly less toward the periphery. We may thus assume that in other auimals the fovea, which has the same general arrangement of retinal elements as in man, when present bears the same relation to the more peripheral parts. The human macula, though inferior to the fovea, sees objects more distinctly than the peripheral parts, and we may reasonably say that in general the area centralis bears this relation to the other parts of the retina.

The peripheral part serves as a sentinel, for it perceives objects in motion more easily than objects at rest. Moving objects attract all animals more quickly than stationary ones, and this is especially true in those animals whose retinal development has not proceeded beyond the differentiation of an area. Only those animals which possess a fovea seem to have the power of quiet and close discrimination of an object at rest.

In speaking of the powers of sight in the different classes of vertebrates, I can do no better than quote from the original article of which the foregoing is a summary.

Fishes as a rule depend upon sight for their food, excepting such as the shark, which depends almost wholly on its smell. This class of vertebrates does not, however, usually possess a fovea.

How distinctly they see we can not say, but we know that the trout quickly takes the fly when thrown on the water, or the pickerel the whirling spoon as it is drawn before it. They see the objects while in motion and are apparently unable to distinguish them from the real article of food. An experience in fishing

confirms the fact that a pickerel will not bite at a motionless spoon-hook. The retina of these fish has simply a thickening or area at the axis of vision.

A somewhat similar experiment can be tried with the frog or toad. If one attaches a bit of red flannel, a green leaf or any other small object to a thread and dangles it before a frog he will quickly jump for it. A toad may be fed on meat in a similar way, but in no case will the meat be taken unless it is in motion. Neither do these animals show any marked power of discrimination by sight. They will jump at any small moving object and are apparently not able to distinguish, till they have it in their mouths, whether it is an article of food or a pebble. Investigations again show the presence of an area and absence of a fovea.

In some of the reptiles, however, a marked difference in power of discrimination by sight is noticed. Experiments were made wholly on a small lizard (horned toad). If a dead fly were put before him when he was hungry he would eye it closely for a brief time then quickly take it. His aim was also certain, never missing his mark, while that of the ordinary toad was more at random, throwing out her tongue indiscriminately at moving objects. It is true the lizard was attracted more by a live and moving fly than by a dead, motionless one, but he also had the power of perceiving things at rest. This little creature possessed a sharp and well defined fovea.

In general, bird's eyes are almost as perfect as man's, and, likewise, the optic lobes are even greater in proportion to the size of the body than that of man. It is true that the bird often catches flies as they buzz about, but it also inspects each leaf carefully above and below for a worm or bug which may be there in hiding and which it seldom fails to recognize. The hawk as it soars high in the heavens sees the snake, rat or mouse in the grass and is frequently seen to dart and secure its prey. Very acute sight is present in all birds and especially in birds of prey.

A great difference exists in the power of sight in mammals. The primates possess the power of most acute vision. Many of the mammals depend on smell and hearing more than on sight. The dog picks his master out of the crowd by smell, so does the sheep her lamb. Sight in this case being only partial recognition and they are not sure until they have confirmed their sight by the sense of smell. The same is true of the cow, for she must smell of the strange cow when introduced into the herd. The horse is cured of his fright by smelling of the object which caused it. In all these cases we find a motion of the ears showing that the animal is not only using sight and smell but also hearing. Mammals in general do not recognize a man by sight if he remains quiet, but the crow easily sees

him and does not fail to distinguish his stick from a gun. The dog looks into your face, but you can not tell whether he is looking into your eyes or at your mouth. He has an indefinite gaze, and, like most mammals, is not satisfied with the sense of sight alone, but must confirm and improve with the sense of smell and hearing.

In conclusion, we may say, that though all animals may have the power of accurate observation, yet the power to perceive the delicate lines and shades of an object distinctly seems to reside only in those forms whose retinal development has reached the highest stage, that is, a fovea centralis.

INDEX.

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